DRAFT
SYSTEM ENGINEERING MANAGEMENT PLAN

For the

I-580 EASTBOUND EXPRESS LANES PROJECT

Contract No: _____

Date Submitted: October, 2009

ACCMA Approval	Signature	Date
FHWA Approval	**Signature**	**Date**

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ACCMA	Alameda County Congestion Management Agency
AVI	Automatic Vehicle Identification
AVC	Automatic Vehicle Classification
BATA	Bay Area Toll Authority
Caltrans	California Department of Transportation
CCTV	Closed Circuit Television
CHP	California Highway Patrol
CMP	Configuration Management Plan
COTS	Commercially Off-The-Shelf
CSR	Customer Service Representative
CTOC	California Toll Operators Committee
DDD	Detailed Design Documents
DDR	Detailed Design Reviews
DMS	Dynamic Message Sign
DRDS	Dynamic Rate Display Sign
DOS	Denial-Of-Service
DSRC	Dedicated Short Range Communication
ED	Executive Director
EL	Express Lanes
ETC	Electronic Toll Collection
ETS	Electronic Toll System
FasTrak™	FasTrak™ is the Electronic Tolling System that is utilized in California
FAT	Factory Acceptance Test
FIFO	First In First Out
FHWA	Federal Highway Administration
FMAS	Facility Management and Accounting System
GUI	Graphical User Interface
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
Integrator	ETS Contractor
ISO	International Standards Organization
IT	Information Technology
ITS	Intelligent Transportation System
LED	Light Emitting Diode
LOS	Level of Service
MF	Mixed Flow (lanes)
MOMS	Maintenance On-line Management System
NTCIP	National Transportation Communications for ITS Protocol
OICT	On-site Integration and Commissioning Test
PDA	Personal Digital Assistant
PDD	Preliminary Design Document

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PDF	Portable Document Format
PDR	Preliminary Design Reviews
PM	Project Manager
PMD	Project Management Document
PQM	Project Quality Manager
QA/QC	Quality Assurance/Quality Control
QM	Quality Management
QMP	Quality Management Plan
RCSC	Regional Customer Service Center
RTMS	Remote Traffic Microwave Sensor
RF	Radio Frequency
RFID	Radio Frequency Identification
RFP	Request For Proposals
RSE	Roadside Equipment
SEMP	System Engineering Management Plan
SOV	Single Occupant Vehicle
SSD	Software Specification Document
Tag	In-vehicle FasTrak™ Transponder
TCP/IP	Transmission Control Protocol/Internet Protocol
Title-21	Mandated standard that all ETSs in California must adhere to
TDC	Toll Data Center
TMC	Traffic Management Center
TP	Transaction Processor
TPS	Transaction Processor System
Transponder	Small in-vehicle electronic device that is used to pay tolls
TZ	Tolling Zone
TZC	Tolling Zone Controller
UPS	Uninterruptible Power Supply
VDS	Vehicle Detection System
VPN	Virtual Private Network
WAN	Wide Area Network
WBS	Work Breakdown Structure

GLOSSARY

- System requirements – are those specific requirements that must be met by the equipment and/or system provided by the Integrator as described in the RFP and other contract documents.
- Functional requirements – are those requirements defined by functional attributes. These requirements, which are also defined in the RFP and contract documents, shall be met by the equipment and/or system provided by the Integrator.
- Life-cycle – is the period of time in which ETS hardware is expected to operate within the stated requirements of the Integrator's Proposal.
- Phase – is a step in the ETS systems engineering process that must typically be completed and deemed acceptable prior to commencing work on the next phase.
- Tasks – are the intermediate steps that collectively constitute a phase.
- Activities – are the steps required to complete a task.
- Milestones – are specific dates assigned to the planned accomplishment of activities, tasks, or phases in order to measure whether or not the schedule requirements have been met.
- Overall Project Schedule – is the schedule that includes all task completion milestones for the entire Express Lanes Project, including all of the required roadway design and construction work.
- Integrator Project Schedule (Development and Deployment Plan) – is the schedule that presents the various ETS completion tasks with dates and milestones that shall be met by the Integrator and must adhere to the important dates in the Overall Project schedule.
- Installation Plan Schedule (Deployment Plan) – is the schedule that indicates how the Integrator will install equipment and deploy software on the Express Lanes Project. Specific step-by-step sequenced scenarios for the installation of roadside equipment, communications network, TDC equipment, enforcement equipment, and the TMC subsystem shall be provided in this schedule, which will be a sub-schedule of the Integrator Project Schedule.
- Internal quality audits – are periodic audits that will be performed by the Integrator either on their own or upon request by the ACCMA ED.
- Threats – are external actions and/or circumstances that if and when they occur might adversely impact the performance of the ETS.
- Vulnerabilities – are ETS design features that might be susceptible to unpredictable or even adverse performance in the presence of a threat.
- Risks – are any potential issues, including the combination of threats and vulnerabilities, that could jeopardize the Express Lanes Project, or more specifically jeopardize the ETS operation, its individual components or various subsystems.

- System Development – is the process of developing the actual ETS, including the development, test and integration of the ETS software.

1. PURPOSE OF DOCUMENT

The System Engineering Management Plan (SEMP) and associated documents have been developed as guidelines to define the various technical planning and control, systems engineering process, transitional critical technologies, and the integration of the Express Lanes (EL) systems engineering effort. This engineering effort will be the full contractual responsibility of the chosen Electronic Toll System (ETS) Integrator.

The engineering process that will be implemented in support of the design, development, testing and deployment of the I-580 EB EL ETS will be important to ensure a successful project. That engineering process is identified in this SEMP and the guidelines presented in these documents will be clearly conveyed to the selected ETS Integrator (Integrator) through the Request for Proposals (RFP) and other contract documents. The work of the selected Integrator will be monitored closely to ensure project success.

The ETS will include the implementation of various technologies, including FasTrak electronic tolling equipment, vehicle detection equipment, system enforcement devices, and various types of communications systems. The Integrator will be selected to perform the ETS design, development, integration, testing and deployment. The Alameda County Congestion Management Agency (ACCMA) will be responsible for ensuring that the delivered ETS operates according to the RFP and the other contract requirements. The ACCMA will use consultants to provide tolling system technical and project monitoring assistance to ensure that the EL system operates as planned.

2. SCOPE OF PROJECT

The Express Lanes (EL) is the conversion of the proposed I-580 eastbound High Occupancy Vehicle (HOV) lane to a High Occupancy Toll (HOT) lane referred to as Express Lanes (EL) for this project. The EL project limits are from just west of the Hacienda Drive Interchange to just east of the Greenville Road Interchange in Alameda County. The California Legislature under AB 2032 authorizes this conversion to improve travel efficiency in the corridor and provide more options to individual travelers. The ACCMA has been authorized to administer, design, construct, operate and maintain the EL. The California Department of Transportation (Caltrans) is responsible for the design and construction of the eastbound I-580 HOV lane.

This portion of I-580 was selected for a EL implementation because it is expected to experience significant traffic congestion during the morning peak period at the time in which the EL will be opened to traffic. Conversion of the proposed I-580 eastbound HOV lane to the EL will be accomplished using proven technology, traffic engineering expertise, and dynamic pricing to more efficiently use existing roadway capacity to improve traffic flow and travel times in the corridor as well as optimize revenue for future transportation improvements, including transit, in the corridor.

Currently, the proposed eastbound HOV lane will allow continuous access for eligible vehicles to and from the mixed-flow (MF) lanes. In addition, the proposed eastbound

HOV lane will serve as a mixed flow (MF) lane during off-peak travel periods. Under the EL configuration all eligible users (HOVs, motorcycles, buses and toll-paying Single Occupant Vehicles (SOVs) will be able to access the EL at designated locations during the hours of operation. HOV vehicles will continue to use the Eastbound I-580 EL for free.

Solo drivers who want a more convenient and reliable trip can choose to use the EL for a fee. The fee will vary depending on the traffic operating conditions in both the EL and the MF lanes. Two-axle, delivery-type trucks will also be allowed to use the new converted facility for a fee, but trucks with three or more axles will not be allowed to use the EL.

Under this EL concept:

- The new EL are designed to operate 24 hours a day, seven days a week, in the eastbound direction, pending changes to the current EL legislation.
- The number of access points to and from the EL will be limited to pre-designated locations.
- The assessed toll will be dynamically adjusted based on real-time traffic levels in both the EL and in the MF lanes to ensure that EL traffic flow will be maintained at the appropriate level of service.
- The toll price will be posted on highly visible Dynamic Message Signs (DMS) which will be located upstream from the entrances to the EL allowing SOV motorists to choose whether or not to use additional capacity in the lane for the posted toll rate.
- Static signs will clearly identify the entrance and exit points of the EL.
- The tolling operation will be fully electronic (FasTrak) with no means for cash payments.

The overall toll system will be owned and operated by the ACCMA and will consist of the roadway equipment, the Toll Data Center (TDC), and various system enforcement tools. The EL concept will utilize the following proposed technology solutions:

- Dynamic pricing will control the toll rate based on the level of congestion in the EL and in the MF lanes.
- Approximately 26 VDS locations will be used in the eastbound I-580 EL and 13 VDS locations in the MF lanes to continually monitor traffic density and speed in the EL and travel time information in the MF lanes.
- The technology configuration will involve the use of DMSs that will display the current toll rate ahead of the EL access points.
- A communication network will be implemented to support the Roadside Equipment (RSE) sites that read FasTrak transponders. The RSE sites will be equipped with a Tolling Zone Controller (TZC). The TZCs, which will include a computer, will manage the transponder detection process (FasTrak antennas and readers), vehicle detection, system communications, data collection at each Tolling Zone (TZ), data storage and the periodic transmission of tolling zone data to the TDC.

- The Transaction Processor (TP) subsystem will reside at the TDC and will merge individual transaction records into single, one-way trips.
- The TDC will collect the tolling zone Electronic Toll Collection (ETC) transactions, develop trips from the transaction records and transfer toll trip data from the I-580 EB EL system to the Bay Area Toll Authority (BATA) Regional Customer Service Center (RCSC) for FasTrak account processing. EL trip data will be sent on, at least, a daily basis. BATA will provide payment to the ACCMA based upon the toll payments that are embedded in the EL trip records that were sent for processing.
- Tolls will be collected through the use of FasTrak transponders and account management services will be performed by BATA's RCSC. The RCSC will handle FasTrak account management activities, distribution of transponders, payment processing, security/access and other ETC system financial functions.

3. TECHNICAL PLANNING AND CONTROL

The ACCMA will be responsible to ensure that the ETS is properly designed, developed, integrated, tested and deployed. The ACCMA shall use the services of consultants to make sure that this takes place. Even though the Integrator shall be contractually responsible to develop and closely adhere to their own engineering practices, the ACCMA and their consultants will have the capability to review and approve the Integrator's engineering practices and closely monitor these activities to ensure full compliance of the various procedures. It was determined that the best way to ensure successful system implementation was to develop various systems engineering guidelines that will be submitted to and discussed with the Integrator. The Integrator will be required to submit their planning and design work consistent with these guidelines. In order to convey to the Integrator the types of system engineering practices that they should utilize, various SEMP guideline documents have been developed.

Provided below is a list of the SEMP documents that have been developed in support of the engineering process for the EL Project:

1.Quality Management Plan Guidelines;
2. System Development Plan Guidelines;
3. Data Security and Safety Plan Guidelines;
4. Configuration Management Plan Guidelines;
5. System Integration Plan Guidelines;
6. Verification (Test) Plan Guidelines;
7. Deployment Plan Guidelines; and
8. Electronic Toll System Requirements.

The *Concept of Operations* document and *Enforcement Plan* documents will be submitted for review and comments under separate cover. Although they are part of the system engineering documents, these documents are under separate cover and are not included with this SEMP submittal.

The draft versions of each of these SEMP documents are subject to ACCMA approval and are attached as appendices. As described above, the SEMP documents have been developed to be used as guidelines to define the various technical planning and control, systems engineering process, transitional critical technologies, and the integration of the EL systems engineering effort. This engineering effort will be the full contractual responsibility of the chosen ETS Integrator.

Presented below is a brief description of each document.

- **System Concept of Operations Plan** – This document provides a high-level system operational overview of the EL Project. This Plan describes the operating parameters of the EL, which organization will be responsible for the EL deployment (ACCMA), which group will construct the HOV lane (Caltrans), how the ETS will be designed and developed, the various external interfaces to the Bay Area Toll Authority (BATA) Regional Customer Service Center (RCSC) for FasTrak account management processing, the interface to the Caltrans Traffic Management Center (TMC), the system enforcement process, etc.

- **Enforcement Plan** – This document provides the details pertaining to how the EL system will be enforced by the California Highway Patrol (CHP) officers. The actual enforcement equipment, software, integration testing and installation plans will be provided by the Integrator as part of their systems engineering documentation submittals.

- **Quality Management Plan Guidelines** – This document provides various guidelines that need to be implemented by the Integrator to ensure that all necessary quality assurance (QA) and quality control (QC) processes are identified, maintained and adhered to by the Integrator in order to ensure that the delivered ETS operates according to the system performance requirements that are presented in the RFP and the other contract documentation.

- **System Development Plan Guidelines** – This document provides details regarding how the Integrator will conduct the actual hardware and software design, system development, shop testing, integration and factory testing of the ETS to ensure that it is designed and developed properly. These guidelines will be used as the basis for the Integrator to develop their more detailed ETS Development Plan, including proper management controls such as internal reviews, schedules and a Work Breakdown Structure (WBS).

- **Data Security and Safety Plan Guidelines** – This document includes various built-in data security measures that need to be incorporated into the ETS. This Plan will also identify the ways in which the system design, development and deployment will be performed to ensure that the work is conducted in a safe manner.

- **Configuration Management Plan Guidelines** – This document provides various guidelines pertaining to the ETS configuration and how the Integrator should

develop, maintain and adhere to internal configuration management procedures and processes to ensure that system design, development, enhancements and modifications are deployed in a manner that prevents additional problems from affecting the system operation.

- **System Integration Plan Guidelines** – This document provides the required details regarding how the various equipment, subsystems and overall system will be fully integrated and tested by the Integrator to ensure that a fully integrated and operating system is deployed that meets all of the functional requirements that are presented in the RFP and the other contract documents. This pertains to the hardware and software components of the EL system.

- **Verification (Test) Plan Guidelines** – This document provides the various system testing and validation requirements that will be implemented by the Integrator to ensure that the delivered ETS meets all of the system requirements that are presented in the RFP and the other contract documents.

- **Deployment Plan Guidelines** – This document provides all of the details pertaining to how the EL system will be prepared for installation, installed, tested and opened to traffic. The actual equipment and software development, integration testing and installation plans shall be provided by the Integrator as part of their required documentation submittals.

- **Electronic Toll System Requirements** – This document describes the functional ETS requirements, various operating business rules, and interfaces to other external systems. The ETS requirements shall be used by the Integrator as the basis for developing their proposal and to effectively design, develop and implement the new EL ETS.

The Integrator will also be responsible for the development of a comprehensive training plan. The training plan will include all required training activities, for the ACCMA customer service representatives, the Toll Data Center staff, ACCMA operations staff, Caltrans Traffic Management Center staff, ETS maintenance technicians, etc. The training plan will be submitted for review and approval by the ACCMA ED. This plan is discussed in more detail in the Deployment Plan.

4. SYSTEMS ENGINEERING PROCESS

The ACCMA will utilize a systems engineering process that ensures that the Integrator develops and closely adheres to a design process that is acceptable to the ACCMA. The design process approach to be used on this Project for the software development process is the V-Cycle Model, which is described subsequently in both this document and the appendices. The V-Cycle System Engineering process includes engineering for the ETS equipment, software development, integration testing, documentation development, and

installation and deployment of the ETS. The ACCMA will utilize the services of consultants to ensure that this process is followed. Presented below are the four areas of engineering analysis that will be implemented by the ACCMA:

1. System Requirements Analysis – As described previously in this document, the ***EL System Concept of Operations*** document has been developed and is pending approval by the ACCMA. The information presented in this document will be provided to prospective Integrators as part of the RFP submission. The information presented in the ***Concept of Operations*** document was used during the development of the various EL requirements, which are functional in nature. The ACCMA will provide the draft system requirements document to the experienced tolling system design staff at Caltrans and BATA to obtain important feedback and make certain that the requirements can be met by prospective ETS bidders. The system requirements will be provided to prospective Integrators as part of the ETS RFP package.
2. Sub-System Functional Analysis – As part of the system requirements development process, the ACCMA consultants will expand on the system requirements to the sub-system level. The consultants will ensure there are no conflicts between the system and the sub-system related requirements. It is expected that the various external interfaces, including to the BATA RCSC, the Caltrans TMC, and the enforcement system equipment, will be identified at this point in the requirements development process.
3. Design Synthesis – The Integrator will then use the various system and sub-system related functional requirements as the basis for designing the ETS. The ACCMA and their consultants shall closely oversee the Integrator's design process and will conduct several rounds of testing to ensure that all identified requirements are being met. It is envisioned that the ACCMA's consultants will utilize the comprehensive requirements trace matrix, which will be developed by the Integrator, as the guide to ensure that the Integrator is designing the ETS correctly.
4. System Analysis – During the Integrator's ETS design process, the ACCMA's consultants will monitor this activity to quickly identify possible technical problems with proposed equipment, commercial off-the-shelf (COTS) hardware or software, and Integrator application software. If technical trade-offs need to be implemented, the Integrator shall follow these procedures, which will be clearly identified in the ETS RFP. The ACCMA will be required to approve the requested technical trade-off as proposed by the Integrator and recommended by the consultants.

The ACCMA will develop and implement an internal document and drawing review and approval process that will be applied to the systems engineering process of the EL Project through system acceptance. The ACCMA's Executive Director (ED) will have the contractual and legal authority to sign off on all system engineering related aspects of the Project. The typical approval process will be as described below:

1. The Integrator shall be required to provide a particular document and/or drawing within a certain timeframe as will be stated in the ETS RFP.

2. The ED, or his/her designee, and the ACCMA's consultants will carefully review and provide comments and/or suggested modifications on the document or drawing. The consultants will then compile all of the comments into a matrix/database.
3. The consultants will provide a recommendation to the ED, which might be to approve the document/drawing or ask the Integrator to make changes and re-submit the document for a second round of review.
4. The ED will then make the decision whether or not to officially approve the document/drawing and will inform, in writing, the Integrator Project Manager of that decision.

To enhance the ability for the ACCMA to closely track the Integrator's system engineering process, the Integrator will be required to provide a document management tool. This program will support the storage and retrieval of all types of project documents, including correspondence and e-mail messages. The program will also have the capability to segregate ACCMA documents from general project documentation that can be accessed exclusively by ACCMA and consultant staff. It is envisioned that this system will be web-based to allow the users to access the documents and files remotely to better facilitate the Integrator Contract oversight task.

5. TRANSITIONING CRITICAL TECHNOLOGIES

The ACCMA ED and Express Lanes (EL) consultants are aware of the risks associated with the potential technology transitioning process. Much time has been spent during the project documentation development process to consider this important factor. Based on the specific technology considerations for the EL Project, most of the technologies to be incorporated into the ETS are all very mature and have been in successful operation for many years. These ETS technologies include the use of a Title-21 mandated Dedicated Short Range Communications (DSRC) FasTrak transponder detection process, vehicle detection equipment, devices to determine vehicle travel times, tolling zone beacons, Closed Circuit Television (CCTV) equipment, and DMSs.

One of the ETS technologies that will require detailed analysis is the system enforcement equipment, which includes handheld enforcement devices. Both of these pieces of equipment, and their associated software, are currently in the early stages of use at other facilities. A procedure to deal with possible technology swapping will be clearly identified in the ETS RFP. The ACCMA will have approval rights for the technology transfer process and for the technology that is ultimately chosen by the Integrator. The ACCMA's consultants will be involved in this process and will provide technology recommendations to the ACCMA.

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6. INTEGRATION OF THE EXPRESS LANES SYSTEM

The ETS RFP will clearly describe the various system integration requirements. The Integrator shall explain very clearly in the Integration Plan the various methods that they will use to ensure successful integration of the developed components into a fully

functioning ETS that meets the requirements from the RFP and the other Contract documents. The various systems engineering process steps shall be detailed and adhered to by the Integrator during the design, integration, verification/testing, deployment and training phases required to support the operation and maintenance of the new Express Lanes (EL) ETS. The Integrator shall provide information that confirms that they will adhere to each of these engineering steps. The ACCMA and their consultants shall closely monitor the integration process to ensure that it is being performed correctly.

7. SYSTEM OPERATIONS AND MAINTENANCE

The Express Lanes (EL) ETS operations and maintenance requirements will be clearly described in the ETS RFP. The Integrator will be required to prepare and submit an Operations and Maintenance Plan, which will be reviewed and approved by the ACCMA. The Integrator shall clearly explain in the Operations and Maintenance Plan the methods that will be used to effectively operate and maintain the ETS consistent with the RFP and other contract document requirements. This Plan will be followed by the Integrator who will be responsible for EL system operations and maintenance during the 12-month warranty period. The ACCMA and their consultants will closely monitor the operations and maintenance effort to ensure that it is being performed correctly.

8. CONCLUSIONS

In conclusion, the Express Lanes (EL) engineering process that will be used during the ETS design, development, integration, testing and deployment phases of this project is critical to ensure success. The processes identified herein will be described fully in the ETS RFP. The ACCMA and their consultants will make certain that the chosen Integrator closely adheres to the guidelines and requirements that are presented in this SEMP and its appendices.

A. QUALITY MANAGEMENT PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

QUALITY MANAGEMENT PLAN GUIDELINES

PLAN GUIDELINE SECTIONS:

1. **GENERAL**
2. **ROLES AND RESPONSIBILITIES**
3. **QUALITY ASSURANCE AND CONTROL REVIEWS**
4. **QUALITY ASSURANCE AND CONTROL MILESTONES**
5. **SYSTEM INTEGRATOR CONTROLS**
6. **CORRECTIVE ACTIONS**
7. **QUALITY AUDITS**
8. **TYPICAL QUALITY ASSURANCE & CONTROL CHECKLISTS**

1. GENERAL

These Quality Management Plan (QMP) guidelines will identify the Express Lanes (EL) electronic toll system (ETS) quality related objectives, including plans to achieve and measure these objectives. It will establish the roles and responsibilities of each group that will work on this project and define the different types of quality-related processes to be implemented and adhered to by the ETS Contractor (Integrator).

This QMP describes the quality procedures to be followed by ACCMA management and the selected Integrator in carrying out and successfully completing the ETS integration work on the EL Project.

2. ROLES AND RESPONSIBILITIES

The Express Lanes (EL) Project overall Quality Management (QM) responsibility shall be distributed among all participants of the program including the ACCMA, the system engineering consultants and the Integrator. However, the Integrator shall be fully responsible to develop the QM procedures and guidelines and strictly adhere to these documents throughout the course of the system design, development, implementation and testing phases of the EL Project. The ACCMA's primary responsibility shall be to ensure that the various QM procedures are followed by the Integrator. This will make certain that the delivered tolling system operates according to the RFP and Contract requirements.

2.1 QUALITY POLICY

The selected Integrator's internal QM program must be compliant with International Standards Organization (ISO) 9001:2008 or an equivalent standard. The QM Plan developed by the Integrator, and reviewed and approved by the ACCMA, shall be compliant with the Integrator's QM program.

2.2 QUALITY MANAGEMENT ORGANIZATION

All members of the EL Project team are responsible for producing work of the highest quality. The Integrator Project Manager (PM) has the overall responsibility for guaranteeing that the QM procedures are adhered to. The PM will have the assistance of the Integrator's Project Quality Manager (PQM), who will have responsibility for implementing and monitoring the QM process.

The PM and the PQM shall also have a direct interface on all quality-related matters with the ACCMA Quality Assurance/Quality Control (QA/QC) project staff. Listed below are suggested starting points for defining the QM's organizational responsibilities required for the program's success.

2.2.1 ALAMEDA COUNTY CONGESTION MANAGEMENT AGENCY (ACCMA)

The ACCMA ED shall have full contractual responsibility for all EL QM activities and will work closely with the consultant staff and Integrator personnel to make certain that full quality control is adhered to during the system design, development, integration, testing, installation and deployment phases of the EL Project.

2.2.2 PROJECT CONSULTANT STAFF

The ACCMA's EL program management and tolling system consultant staff shall have, at a minimum, the following roles and responsibilities:

1. Shall ensure quality objectives are met on this project.
2. Shall identify each of the applicable policies and procedures as part of the ISO 9001: 2008 Standards or an equivalent standard.
3. Participate in all facets of QA/QC activities and provide recommendations to the ED for verification of QM features of the project.
4. Provide QM guidance to the Integrator and ACCMA staff during the system design, development, integration, testing, installation and maintenance process.
5. Provide regulatory guidance for QM related requirements in conjunction with ACCMA staff.
6. Maintain a liaison with the ED and Integrator staff to incorporate additional QA/QC procedures throughout the EL system design, development, integration, testing, installation, maintenance and possibly operations phases of the Project.

2.2.3 INTEGRATOR SYSTEMS ENGINEERING STAFF

The ETS System Integrator engineering personnel for the EL Project shall have the following roles and responsibilities:

1. Develop a detailed QM manual based on the ISO 9001 1994 standards for review and approval by the ACCMA.
2. Identify and document the relevant specific QA/QC procedures and guidelines that are necessary to satisfy all of the project-specific operating requirements.
3. Identify the control documents for management of quality.
4. Carry out project-specific QM procedures enabling quality audits.

3. QUALITY ASSURANCE AND CONTROL

3.1 METHODOLOGIES AND STANDARDS

In addition to the policy and people, the QMP will define the project's QM procedures. The QM procedures will be developed by the Integrator, and subject to ACCMA review and written approval. They shall provide the specific approach to ensure that quality objectives are met on the project in accordance with each of the applicable ISO 9001 1994 Standards (or an equivalent standard) policies and procedures. The Integrator shall apply these QM procedures to the Express Lanes (EL) Project.

3.2 QUALITY ASSURANCE AND CONTROL

The QMP shall be developed and a QA/QC program implemented during all phases of the EL Project. This QA/QC program shall indicate how the Integrator will address changes to the scope of services on the project requested by either the ACCMA or the Integrator.

3.3 QUALITY ASSURANCE AND CONTROL MILESTONES

The Integrator RFP will include the system design, development, testing and implementation milestones for the EL Project. Reaching each of the specified milestones will trigger a pre-determined payment from the ACCMA to the Integrator. The QM and QA/QC procedures and guidelines will be clearly described in the proposal and in the Contract to make sure a process is in place that will allow the ACCMA to clearly determine whether each milestone has been reached.

4. SYSTEM INTEGRATOR CONTROLS

The Integrator PM shall direct the implementation of the approved QMP, which will execute the following QM and QA/QC procedures to maintain a proper level of quality throughout the project.

4.1 DESIGN CONTROL

Quality process as defined in the QMP shall govern the control of the system design, development, integration, testing, implementation and maintenance of the work to be completed on this project.

4.2 DOCUMENT AND DATA CONTROL

The Integrator shall implement various document and data control procedures as part of the QM and QA/QC process. The Integrator shall track electronic communications, physical documents, and communication records generated by their staff on the project. Procedures will be developed by the Integrator to guarantee that this takes place. The Integrator shall also provide the ACCMA with a hard copy of all project correspondence that they develop, including system design documents, drawings, letters, e-mails, etc.

4.3 PURCHASING CONTROL

Any direct purchasing for the project shall follow the QMP direction which applies. All approvals and processing of purchases charged to the project shall adhere to the existing ACCMA policy. In the event that subcontractors are used on the project, the procedure to procure and control these services and/or equipment or software shall be established according to the QMP. Most project-related purchases for materials used by the Integrator shall be managed by the Integrator and will comply with the various QM and QA/QC procedures established by the Integrator and approved, in writing, by the ACCMA.

5. CORRECTIVE ACTIONS

The QMP shall clearly identify the various processes and products that will be used by the Integrator to identify any defects, and methods of corrective action to resolve such defects.

The QMP will determine the ISO standards that should be followed in the Integrator's QM and QA/QC procedures and guidelines. The QMP shall also identify specific products to be used to track, monitor, and document corrective actions in a structured manner.

6. QUALITY AUDITS

Internal quality audits are required to prove that the QA/QC procedures are working effectively. Audits will be performed by the Integrator PM, the PQM, or another designated person. Audits on areas that are within the scope of influence of the Integrator PM and specific QM team members shall be conducted by personnel that have not conducted actual work on the system design, development, etc. This will ensure that the staff that has performed the actual work is not checking the work in question.

Quality audit documentation shall be made available by the Integrator to the ACCMA. The following illustrates the internal quality audit framework that shall be adhered to by the Integrator on the Express Lanes Project:

1. Internal quality audits of components by the Integrator PM and staff will be conducted at an interval not to exceed one month.
2. Quality audits of the major subsystems conducted by the Integrator PM and QM staff shall be conducted at an interval not to exceed three months.
3. The quality audit documentation shall be developed by the Integrator and submitted to the ACCMA for review and approval. Once approved, it shall be distributed to all EL Project team members.

4. The audit documentation shall contain, at a minimum, recommendations for improvements, if any, to the various quality procedures that have been used as the basis for the development of the audit documentation. The documents will be prepared according to the relevant ISO 9001 standards or an equivalent standard.
5. The audit shall follow an established format proposed by the Integrator and approved, in writing, by the ACCMA within the QMP.

7. TYPICAL QUALITY ASSURANCE & CONTROL CHECK LISTS

Presented below is a sample checklist for use as part of the quality audit for tolling system design projects. This checklist is for informational purposes only, since the Integrator will develop and use their own detailed checklists as part of the quality audit procedures and guidelines as detailed in the QMP, and monitored by the ACCMA.

Table 1 – Typical Quality Assurance and Control Checklist

YES	NO	Checklist Description
p	**p**	Are project tracking activities in place?
p	**p**	Is project tracking and oversight being conducted?
p	**p**	Are all plan reviews conducted according to plan checklists?
p	**p**	Are all issues arising from peer reviews addressed and properly closed?
p	**p**	Are status and review meetings conducted according to the schedule?
p	**p**	Has a contract Work Breakdown Structure (WBS) that supports all project deliverables and long-term tasks been developed?
p	**p**	Are system changes being managed according to the Configuration Management Plan (CMP)?
p	**p**	Have all deviations from standards and procedures documentation been approved by the ACCMA?
p	**p**	Are project roles and responsibilities clearly defined and adhered to?

B. SYSTEM DEVELOPMENT PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

SYSTEM DEVELOPMENT PLAN GUIDELINES

PLAN GUIDELINE SECTIONS:

1. **GENERAL**
2. **ROLES AND RESPONSIBILITIES**
3. **PROGRAM MANAGEMENT DOCUMENT**
4. **PROGRAM MANAGEMENT IMPLEMENTATION**
5. **SYSTEM CONFIGURATION MANAGEMENT**
6. **SUBCONTRACTOR CONTROL**
7. **INTEGRATOR PROJECT SCHEDULE**
8. **SOFTWARE DEVELOPMENT**
9. **SOFTWARE DOCUMENTATION**
10. **SOFTWARE DOCUMENTATION CONTROL**
11. **CONCLUSION**

1. GENERAL

The Electronic Toll System (ETS) Contractor (Integrator) will develop a detailed and comprehensive System Development Plan (Plan.) The Plan will describe the management methodology required to ensure that the I-580 EB Express Lanes (EL) system development work is conducted properly. The Plan will also include the Integrator's approach to managing the project and the planned software development and integration processes.

2. ROLES AND RESPONSIBILITIES

The Integrator will be solely responsible for designing and developing the Express Lanes (EL) software in a manner that complies with all of the functional system and equipment requirements presented in the RFP and the other contract documents. The Integrator will make certain that the subsystem and full system integration process is conducted to ensure all requirements are met by the delivered tolling system. The ACCMA will closely monitor and approve, in writing, all system design, integration, testing and deployment activities by the Integrator.

3. PROGRAM MANAGEMENT DOCUMENT

The Integrator will be requested to develop a Program Management Document (PMD) to provide the framework for developing and implementing the ETS for the Express Lanes (EL) in a controlled and managed environment. The PMD will describe the project management goals, structure, methods, and reporting process that will be used to monitor and control the overall program. The Integrator shall provide with the PMD a detailed Integrator Project Schedule. The purpose of the PMD is to ensure that the EL ETS is delivered on schedule and within the established budget.

3.1 REFERENCED PROJECT DOCUMENTS

The PMD shall explain the relationships between the following documents, which will be developed subsequently on the Project:

- The Project Installation Plan;
- The System Verification (Test) Plan; and
- The System Design Documents, including the Preliminary Design Document (PDD) and the Detailed Design Document (DDD).

3.2 PROGRAM MANAGEMENT APPROACH

The Integrator will examine the technology risk areas and the management requirements that need to be considered as part of the PMD for implementing the ETS contract specifications within the stated time periods. The Integrator will then detail all of the features and benefits of their program management approach to ensure that the system is delivered on schedule, within the established budget, and that it operates according to the system specification requirements.

4. PROGRAM MANAGEMENT IMPLEMENTATION

4.1 ACCMA PROGRAM RESPONSIBILITIES

Overall scheduling of all field construction activities will be under the direction of the ACCMA. Caltrans will manage the roadway construction activities and has the responsibility to make sure that the roadway contractor coordinates work with the Integrator. Resolution of any conflicts that might arise between the Integrator and the Caltrans contractor will be administered by the ACCMA. The Integrator shall be responsible to the ACCMA for compliance with the ETS RFP and other contract documentation requirements, all drawings, work quality, project schedule, etc. Any subsequent reference to the ACCMA in this document shall also include the possible involvement of their representatives.

4.2 ACCMA WEEKLY MEETINGS

It is expected that the ACCMA will conduct regular meetings with all contractors on the Express Lanes (EL) Project. The meetings will typically be held weekly at a location to be determined by the ACCMA. The purpose of the meetings will be to

review the scheduling and coordination of each of the contractor's work within the requirements of the overall EL construction and implementation program.

The Integrator shall be involved with these meetings during the phases of the EL Program in which they will be involved. The Integrator shall provide an on-site manager during the ETS equipment and system installation phase of the project.

4.3 KEY CONTACTS

The key Integrator program contacts shall be listed in the PMD. The list, which will be subject to approval by the ACCMA, will be updated as changes occur during the project. All requests for changes must be made in writing to the ACCMA. Approval by the ACCMA shall also be in writing. The Integrator's Program Manager, who shall also be approved by the ACCMA, will be made accessible to the ACCMA on a 24 hour-per-day, 7 day-per-week basis, either in person or via mobile telephone.

4.4 INTEGRATOR PROJECT SCHEDULE

The Integrator Project Schedule will define a normal design and development process, the timeline for required program phases and milestones, documentation deliverables, meeting dates, and other deliverables/milestones defined in the ACCMA's Overall Project Schedule (see 4.9 below). To avoid any confusion, the approved ACCMA Overall Project Schedule will supersede all other schedule-related requirements presented by the Integrator on this project. The Integrator Project Schedule shall include the system development activities, tasks, dates, and milestones described in Section 7 below.

4.5 COMMUNICATIONS

The communication requirements between the Integrator and other project staff will be discussed at the Project Kick-Off Meeting. The Integrator will communicate all project-related matters to the ACCMA and consultant staff as directed by the ACCMA ED. The ED will determine whether to hold weekly conference calls with the Integrator and consultant staff, and when these calls will be held.

4.5.1 E-MAIL

E-mail will likely be the preferred method of communication for all program correspondence. The Integrator Project Manager (PM) will be instructed as to which project staff should be copied on correspondence.

4.6 STATUS REPORTING

The Integrator shall provide a Monthly Status Report to the ACCMA, to be submitted on the first working day after the 15th of each month. Reports will be presented according to the status reporting requirements established in the RFP.

4.7 ON SITE INSTALLATION

The Integrator will develop an Installation Plan containing detailed plans and the management approach for the on-site installation team and related activities. The Installation Plan will be subject to the review and approval of the ACCMA.

During the installation phase of the program, the Integrator will provide a resident installation manager accessible to the ACCMA from a local office. This person is a local resource for the ACCMA, their engineers, and other contractors. With direction from the Integrator's PM, the installation manager will assist and follow the program through the initial design, installation, and commissioning phases. The installation manager will be knowledgeable in all aspects of the program, including scope, schedule, and systems.

4.8 EL SYSTEM TESTING

The Integrator will develop and provide detailed test documents in support of the various equipment and system tests that will be performed on this project. The Integrator's test plans and test procedures will contain testing activities, criteria, and the management approach for all system testing, as presented in the System Verification (Test) Plan.

4.9 SYSTEM DESIGN AND DEVELOPMENT

Creation of the EL ETS, as detailed in the Integrator Project Schedule, will follow the V-Cycle Software Development system design and development process, as described below. Project phases and milestones, including those specific to the Integrator, are defined in the Overall Project Schedule. To avoid any confusion, the ACCMA approved Overall Project Schedule shall supersede all other schedule-related requirements and it must be adhered to by the Integrator.

4.9.1 WORK BREAKDOWN STRUCTURE

The Integrator will develop, submit and routinely update a comprehensive work breakdown structure (WBS), which will be used in the Integrator Project Schedule, and will separate large tasks into manageable units for all aspects of the required work to be accomplished by the Integrator. The Integrator will be required to submit WBS details, when requested by the ED, that clearly and concisely describe all facets of the EL project administration, toll system design, system development, testing and implementation work that will be conducted.

4.10 MANAGEMENT REPORTING AND MONITORING

The Integrator shall be expected to use a range of management reports to track the progress of all work activities. The PM will review reports to monitor each activity to troubleshoot real or potential schedule and budgetary issues so they can be addressed before they become problems. When this analysis reveals that work on any single milestone is trending toward greater cost or time than planned, the report(s) will flag the problem, which will then be discussed by the PM with the ED.

In the event that there is an affect on the project cost and/or schedule, these issues can be immediately addressed by the ACCMA.

The Integrator will, on a monthly basis, re-assess the number of calendar days required to complete the remaining work of each task. This assessment will identify the appropriate resources necessary to complete each task, in order to avoid shortages of resources. To supplement the continuing evaluation of each work task, the critical path of the entire program will be evaluated at least monthly to identify any changes or potential scheduling problems.

The Integrator PM will be expected to organize their resources to complete the design, development, integration, test, installation, field test, and commissioning of the EL ETS in accordance with the requirements in the RFP and the Contract documents. The Integrator team will execute the program to fulfill the ACCMA's requirements.

4.11 EXPRESS LANES PROGRAM ACTION ITEMS

For the EL ETS, Integrator staff will record, monitor, and control all program action items. The Integrator will be expected to track and provide the status of all action items on at least a weekly basis.

5. SYSTEM CONFIGURATION MANAGEMENT

The Integrator shall provide strict configuration control on the Express Lanes (EL) ETS Project. Any changes to the tolling system shall be approved, in writing by the ACCMA, and properly documented. A method shall be used to identify the relationship of configuration items to the overall system. System configuration guidelines shall be developed by the Integrator and a copy supplied, for review and approval, to the ACCMA.

Each configuration item, whether delivered to the ACCMA or only used internally by the Integrator, will be issued a control number from the system configuration management database.

5.1 SYSTEM CONFIGURATION APPROVAL

Each configuration document will have a specially formatted approval sign-off coversheet added. The coversheet will clearly identify the document name, the control number, the project number, revision history, and a list of required names of those people that will be reviewing, providing comments and approving that specific document. Adequate space will be made available on the form for signature and date. The signed approval page will then be filed with the hardcopy of the document. Once a document has been approved, an electronic file (PDF) will be made so that no further changes can be made.

6. SUBCONTRACTOR CONTROL

The Integrator will check to make sure that all equipment, supplies, components, systems, subsystems, and any other services procured from subcontractors and vendors conform to the RFP and all other contract requirements. These responsibilities include the establishment of procedures for the selection of qualified suppliers, the flow down of all system design and operating requirements, the internal technical evaluation of the procured item to ensure that it meets all necessary requirements, etc.

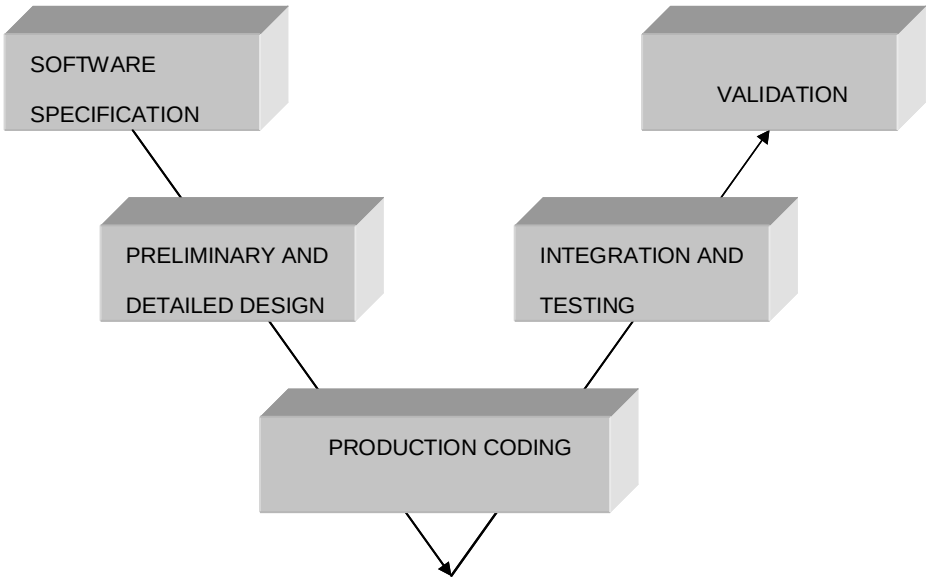
7. INTEGRATOR PROJECT SCHEDULE

A comprehensive Integrator Project Schedule detailing all system related development tasks, inputs and outputs, shall be submitted by the Integrator as part of the PDD phase of the ETS Development. The Integrator Project Schedule shall be prepared using Microsoft Project, or an equivalent program that has been approved by the ACCMA, and will show easily measurable aspects of work that have clear requirements to be met within the indicated time frames established in the Overall Project Schedule.

If a Critical Path task begins to run behind schedule, all of the following Critical Path tasks might be altered, which would jeopardize all of the remaining work items under that category of the Integrator Project Schedule. Therefore, all Critical Path items shall be kept on schedule by the Integrator. To prevent Critical Path items from disrupting the Overall Project Schedule, the Integrator shall add any and all necessary project staff in order to keep those tasks from slipping.

8. SOFTWARE DEVELOPMENT

The software development process will ensure that the Express Lanes (EL) ETS operates according to the requirements outlined in the RFP and the Contract documents. Software development procedures are typically represented by a phased, chronology-based model. Each software development work phase corresponds to certain development activities, which need to be performed in a sequential manner to ensure program success. The model that will be used on this Project for the software development process is the V-Cycle Model, which is presented below.



The V-Cycle software development model involves a two phase process. The first phase includes the development of the software (the downward leg) and the second phase pertains to the software integration and testing process (the upward leg).

During the first phase, the initial task is to develop the software specifications, which is directly linked to the system functional requirements that are presented in the RFP and the Contract documents. Once the specification is completed, the process leads directly to the preliminary and detailed design tasks. Once the system design is complete, the Integrator then develops the actual software code.

The second phase of the software development process integrates the newly developed software with the system hardware to fully integrate the entire EL ETS. To ensure that the system is properly integrated and complies with the various requirements, the software (and system) is subjected to an extensive test and validation process. Once the testing process proves that the software is developed properly and is fully integrated into the entire tolling system, it will be ready to be deployed in a live environment.

8.1 SOFTWARE SPECIFICATION DEVELOPMENT

At the beginning of the software development process it is important to verify and document the definition of requirements. This step allows for the correct development of the software specification. The Integrator shall carefully define the various interfaces between the pieces of system hardware, between the internal subsystems and with external systems. The Integrator shall also be required to separate the software development process into functional components and subsystems and define the information flow between the functions, sub-functions and subsystems. At this point, the Integrator staff shall verify that the hardware and software requirements that are to be implemented are consistent with the required functionality of each component.

One of the most important tasks is to develop the Software Specification Document (SSD). This initial work effort will clearly and comprehensively define all of the ETS related software requirements. This would include each piece of equipment and subsystem in the tolling system, the roadside ETC antennas and readers, the tolling zone lane controllers, the vehicle detection station equipment, the video surveillance subsystems, the handheld enforcement devices, the tolling zone beacons, the TDC hardware and software, the interfaces to the BATA RCSC and the FasTrak account management system, the interface to the Caltrans TMC, the interface to the heldheld units, etc.

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The various requirements should be gleaned from the RFP and the other pertinent Contract documents. The next step is to define the various interfaces between all of the system components and the subsystems. During this task it will be important to identify any potential constraints that might impede system operations.

At this point, it is also important to start laying out the various activities that will be incorporated into the Integrator's internal software validation test process. The outline for this process should be initiated early on in the process since a heavy emphasis of the first phase is to determine the requirements and how the software will be developed to allow the system to operate to meet the stated requirements.

8.2 PRELIMINARY AND DETAILED SYSTEM DESIGN

The next step will define the system software architecture by strategically breaking the software into modules. This will enhance the software development, integration and validation processes. The next task is to verify that all the requirements that are stipulated in the SSD have been taken into account.

The Integrator shall define the overall structure of the ETS and data. Integrator staff shall set up the software integration and validation strategy, as well as the different scenarios and implementation methods that will be used. It will be important to take into account various maintainability and testability constraints, if there are any.

The design process then continues with the development of the PDD, specifying the internal software and hardware structure and detailing the various interfaces of the components and subsystems that were previously identified in the SSD. At this time, the Integrator should prepare whatever equipment shop tests will be required, such as the software that will be required to support the operation of those pieces of equipment.

Once the PDD has been reviewed, brought to final form by the Integrator and approved by the ACCMA, the next step will be to develop the Detailed Design Documents (DDD). This task will also include coding components and documenting the source code. In particular, the following activities will be addressed, at a minimum, during this task:

- Verifying and completing module interfaces;
- Defining the internal structure of the modules;
- Installing detailed design codes in the shape of comments in the source list; and
- Creating a list of tests to be applied to each of the modules.

8.3 SOFTWARE CODE DEVELOPMENT

This task includes the actual development of the EL software. This involves translating each DDD module into the programming language that the Integrator has chosen. It will also include developing software to support the various dynamic pricing algorithms that will support the toll price determinations as they are described in the DDD. The Integrator software development group will also ensure that the resulting compilation does not contain any mistakes and is compliant with all known software programming norms.

As the software is being developed, the Integrator software group will also be required to complete the equipment/shop tests to ensure that the newly developed software and EL hardware operates within the specified requirements (from the RFP and the Contract documents). The test scripts used for the equipment/shop tests will be updated by the Integrator by finalizing the procedures defined during the previous phases of the software development process.

8.4 SOFTWARE INTEGRATION AND TESTING

The next task in the process is to conduct full integration testing of the entire EL system. At this point in the process, the software has been developed to about an 80% level and the Integrator software group shall conduct the system and subsystem integration testing process. The integration tests will be performed to ensure that the newly developed software and EL hardware is fully integrated and operates within the specified ETS requirements. The test scripts used for these integration tests will be updated by the Integrator by finalizing the procedures defined during the previous phases of the software development process.

Various work activities during this task are to assemble the software modules and make sure that the software architecture complies with the DDD of the tolling system. Integrator software staff will also prepare for the equipment, subsystem and full system test and validation tasks. Integrator staff shall then carefully test each software component individually and verify conformity to the DDD for each stated operating requirement.

In support of full integration testing, the Integrator software group will integrate the software modules according to the procedures defined in the integration test procedures, as they previously developed. The software group will also validate the system architecture defined during the PPD and DDD phases of the project. Integrator staff shall also ensure that the various software exchanges between the components and subsystems that were identified during the preliminary and detailed design phases are functioning correctly.

If the integration tests reveal any inconsistencies, then corrective measures shall be taken by the Integrator software group. They shall conduct the integration tests again for those areas in which the problems were discovered and corrected to ensure that the defined operating requirements are met. The equipment and system integration process shall be verified via the performance of factory testing by the ACCMA.

Regression testing will be conducted by the Integrator once the software modifications are made to ensure that basic system functionality has not been compromised as a result of a software modification. The integration test documents shall be used as the basis for regression testing. The regression testing will be complete when the results correspond to those expected, and the software modification can then be deployed into the production system.

8.5 SOFTWARE VALIDATION

This task will confirm that the functionality of the software complies with the SSD, the DDD and the other relevant Contract documents. The Integrator will draw up a reference version of the validated software. This will involve running additional tests, by the Integrator, to verify that the software complies with the various requirements. Previously used system test scripts will be used for this testing.

These validation tests will focus mainly on the functionality of each component, subsystem and the overall system as well as the various interface requirements with the BATA RCSC, the TMC, the handheld devices, the ACCMA website, etc. The validation tests shall also verify the performance and endurance of the system equipment and various subsystems and also determine that the full system data loads can be effectively handled.

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When validation has been approved, the first software reference version can be created. The validation test results and the state of the software documentation can then be verified. If this review proves satisfactory, progress to the subsequent system qualification phases can then be authorized, which includes performance of the Factory Acceptance Test (FAT) and the follow up on-site system acceptance tests.

9. SOFTWARE DOCUMENTATION

Software documentation will be provided for each applicable component. This will include textual descriptions, pseudo code, data flow diagrams, flowcharts and functional diagrams. For third-party software, vendor documentation shall be provided. Custom software documentation will include User Manuals and Technical Manuals with operational and module-level descriptions embedded with the source code.

10. SOFTWARE DOCUMENTATION CONTROL

The Integrator shall identify which product will be used for software configuration control and source code management. The chosen version control product should support team development of the software applications. It should also be able to automatically track and store changes to a file so the software code developers are able to view the history of each file, return to earlier versions of that file, and develop programs concurrently. It would also be beneficial to have a product that uses reverse delta technology in order to store only the changes to a file, not each complete version of the file itself.

10.1 PROCESS VERSIONING

All software processes should have a version number associated with them. The version number should be easily obtained by locating the file in question and clicking on the file.

11. CONCLUSION

The System Development Plan, which will be developed by the Integrator, shall include all of the required information to clearly describe the management approach that will be implemented to ensure that the EL ETS development work is conducted properly. The Plan shall include all required information regarding the Integrator's approach to managing the Project, including planned hardware and software development, integration, and deployment processes.

C. DATA SECURITY AND SAFETY PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

DATA SECURITY AND SAFETY PLAN GUIDELINES

PLAN GUIDELINES SECTIONS:

1. **GENERAL**
2. **ROLES AND RESPONSIBILITIES**
3. **DATA SECURITY ENGINEERING PROCESS**
4. **DATA SECURITY ENGINEERING ADMINISTRATION**
5. **DATA SECURITY ENGINEERING ACTIVITES**
6. **DATA SECURITY ENGINEERING TRAINING**

1. GENERAL

Security engineering is a discipline that focuses on the tools, processes, and methods required to design, implement, and test ETSs to ensure that they remain dependable once deployed. In the context of the Express Lanes (EL) Project, it is to ensure that the control and monitoring of the related transportation infrastructure continues unimpeded. Since transportation infrastructure is vital to commerce, public safety, and national defense, it is imperative that the infrastructure be designed and built to survive threats against it. With the increasing use of (and dependency on) computer technology comes new vulnerabilities to the transportation infrastructure to intentional and unintentional threats, primarily due to the sophisticated ways hackers have learned to disrupt networks and software programs.

2. ROLES AND RESPONSIBILITIES

Due to the recommended distributed responsibility for the implementation of security engineering, many parts of the EL project engineering organization will have roles and responsibilities in this area. Listed below are recommended starting points for defining organizational responsibilities in the security engineering domain.

2.1 DATA SECURITY ENGINEERING

The ACCMA ED will have the following roles and responsibilities:

1. Approve the data security engineering-related processes, policies and operating procedures developed by the Integrator for the EL Project.

2. Participate in project design reviews and provide approval for security-related features of project requirements, design, implementation, and testing.
3. Coordinate with industry groups to maintain a knowledge base of present and emerging threats against Information Technology (IT) and transportation assets.

2.2 SYSTEMS ENGINEERING CONSULTANT

Systems engineering personnel for the EL Project shall have the following roles and responsibilities:

1. Monitor the adherence of the systems and software engineering to this Data Security Plan.
2. Offer technical assistance in the area of security engineering.
3. Provide regulatory guidance for security-related requirements in conjunction with ACCMA management staff.
4. Conduct threat analysis with support, as required, from security engineering.
5. Facilitate vulnerability analysis with support, as needed, from security engineering and software engineering.
6. Ensure that security engineering requirements and processes are passed down to project subcontractors.
7. Manage risk analysis to determine the vulnerabilities to be addressed.

2.3 INTEGRATOR PROJECT MANAGER

The Integrator Project Manager shall have the following roles and responsibilities:

1. Create and maintain security engineering check lists to aid in the performance of the security work.
2. Prepare the test plans, and manage test execution of security evaluation and/or accreditation testing.
3. Design and implement countermeasures in accordance with security engineering guidelines and/or policies.
4. Review and evaluate software during design and development phases to identify additional vulnerabilities.

3. DATA SECURITY ENGINEERING PROCESS

Since the EL Project is principally a networked computer system, security engineering should focus on the various processes and methods to protect these networks, computer systems (i.e., hardware and software), and data. These areas are generally addressed under the umbrella of information security. Awareness and practice of information security is imperative to maintain the 24/7 operation of the Electronic Toll System (ETS) in light of potential threats, including those from new technologies.

This document is intended to provide guidance for the overall EL Project security engineering processes, as well as serve as a template for tailoring project-specific security engineering plan.

3.1 SCOPE

Security engineering methodologies need to be applied throughout an organization and project to be effective. Security must be incorporated into the system design throughout the engineering process or the ETS might be vulnerable to any external threat. Similarly, focusing security awareness in only a portion of the Integrator's organization might result in the security mechanisms being applied topically, rather than integrated directly into the design.

From a project life-cycle perspective, it is important to consider security issues and practices during all phases of the project. Ignoring security issues during the system design and development phase could result in costly rework or less effective external solutions to meet security certification requirements. Security engineering is an integrated discipline to be used during the system design, development and deployment process. It can be significantly more expensive, and have severe schedule impacts, to attempt to remediate security issues late in the project life-cycle.

Similarly, it is important to distribute awareness and practice of security engineering across the ACCMA organization and Integrator staff. Concentrating all responsibility for design, development, implementation, and testing of security-related functionality in a specialized organization or individual will not yield a robust solution. Security engineering affects all engineering disciplines and responsibility should be distributed across the engineering organization in more detail.

Another dimension of the security engineering scope to consider is project type. Since security engineering is partly based on risk analysis, it is logical to assume that projects might require varying degrees and applications of security engineering. Express Lanes projects are particularly vulnerable because they utilize a distributed system with many touch points exposed to the public and there is a revenue collection component. The trend of providing public access to transportation IT via the Internet, and advances with intelligent vehicles, also increase the security risk over traditional system design projects.

3.2 SECURITY ENGINEERING APPROACH

Security engineering is fundamentally risk management – identifying possible vulnerabilities that might be exploited by potential threats and thereby adversely impact the ETS operation, and then determining practical solutions to protect the ETS against such threats. This process has been formalized into the threat-vulnerability-countermeasures methodology. With this process, potential threats to the system are identified, the system is analyzed to determine vulnerabilities to potential threats, and countermeasures are designed to mitigate the vulnerabilities to those threats.

The challenge for the ACCMA in this process is to determine the extent to which each identified vulnerability should be addressed. It is impractical, both from an affordability and operational impact standpoint, to completely address all vulnerabilities within a system. The goal is to assess the affect on the system mission, along with the probability

of the threat, and then design countermeasures whose cost and affect on system operation are proportional. The approach should minimize the vulnerabilities most likely to occur, rather than necessarily protect against all conceivable threats.

A threat analysis will be part of the Integrator system design and development process. Threats should be viewed as part of the system's operational context. Vulnerabilities and countermeasures should be integral considerations to the design, development and implementation of the ETS and security evaluation, and accreditation must be part of the system integration and testing phases.

4. DATA SECURITY ENGINEERING ADMINISTRATION

4.1 ORGANIZATIONAL STRUCTURE OVERVIEW

The most effective security solution is one where all of the engineering disciplines participate. Thus, the greatest asset in operating a secure system is creating awareness by the designers, operators, and users. The ED should ensure that security concerns are included in the criteria used to assess the quality and completeness of the EL Project.

While most of the security engineering effort will be performed by the Integrator engineers tasked with the design, development and implementation of the ETS, the ACCMA will use consultants that are responsible for ensuring the quality and compliance of the security engineering work performed.

4.2 SECURITY ENGINEERING MANAGEMENT

The security engineering process will be managed by engineering reviews, audits against applicable policies/standards, and measurement via appropriate metrics. Integrator personnel will bear this management responsibility.

4.3 REVIEWS

In order to integrate security engineering practice across all of the Integrator engineering disciplines, all project design reviews should address security engineering aspects. It is recommended that the Integrator security engineering staff prepare checklists to include in the system design review procedures, in order to assist other engineering disciplines in properly addressing the security domain in their reviews. It is also suggested that the Integrator security engineering staff attend Preliminary Design Reviews (PDRs) and Detailed Design Reviews (DDRs) to properly assess system security issues.

4.4 GOVERNANCE

The ACCMA will approve policy and guidelines developed by the Integrator to govern the execution of security engineering activities. While security engineering plans based on this document are a primary form of governance, it is also good practice to develop additional technical guidelines/policies to ensure uniform compliance with proven best practices as well as flow-down of applicable regulatory requirements.

5. DATA SECURITY ENGINEERING ACTIVITIES

5.1 SECURITY ENGINEERING PROCESS

5.1.1 STANDARD PRACTICES

The ACCMA will approve Integrator developed security engineering guidelines. Integrator engineering staff shall conduct their security engineering efforts in accordance with these guidelines. In addition, project activities shall comply with any security engineering guidelines or other security engineering governance as discussed previously in this document.

5.1.2 PROJECT-SPECIFIC PROCESSES

The Integrator may tailor their security engineering process via the project security engineering guidelines. For instance, the verification process will often be adjusted based on whether the project has external interfaces that are required to conform to formal security policies or regulations. Security verification to industry standards should be conducted for interoperability with external systems or the public. Practices dealing with Internet connectivity may also be modified in cases where the project system does not directly connect to public networks.

5.2 THREAT ANALYSIS

Comprehensive identification and accurate assessment of threats to a system is critical to developing a cost-effective security policy. Without an accurate threat model in place, systems could be overprotected, which might cause system design countermeasures for potential vulnerabilities that never materialize. Two threat model aspects will be discussed; identification of threats, and assessing the capability and probability of the threats.

5.2.1 IDENTIFICATION

Threats must first be identified before meaningful security engineering can be conducted. A matrix will be developed by the Integrator that presents all of the threats that are identified, which will be used later in the process by the Integrator staff. Personnel performing threat identification shall consider potential threats to the system in the following potential categories:

- **Human Threat** – This is a deliberate or accidental act by any person, whether they are authorized to have access to the system or not. It will be useful to further categorize these threats as internal and external to the ACCMA. Examples may include user errors, unauthorized access attempts, data sabotage, etc.
- **Technical Threats** – This is a malicious or accidental attack by external software or network. Common examples would include viruses, worms, Trojans, network level Denial-of-Service (DOS) attacks, etc.
- **Physical Threats** – This is the malicious or accidental damage to a system through physical acts. Examples may include hardware sabotage or failure.

These types of threats primarily affect system availability, as opposed to privacy or confidentiality. This category also normally includes acts of war or civil disturbance.

- **Natural/Environmental Threats** – These are natural or manmade events that damage or impair a system. Common examples include fire, flood, storms (including lightning), and earthquakes.

Sources of threat identification include:

- **Law Enforcement** – The ACCMA security engineering staff should establish an ongoing working relationship with federal, state, and local law enforcement agencies to obtain general and specific threat information.
- **Professional Organizations** – Computer security organizations such as the SANS Institute (SysAdmin, Audit, Network, and Security) and CERT maintain extensive databases of threats and vulnerabilities, and countermeasures.
- **Operations History** – Operational histories are valuable sources of threat information in the analysis of incidents in existing systems.
- **Design Engineers** – The same hardware and software engineers that design the system often have the capability to identify threats to the system so these threats can be mitigated.
- **Hacker Web Sites/Publications** – Spying on potential attackers is effective, but time consuming (the signal-to-noise ratio is quite poor).

5.2.2 ASSESSMENT OF THREAT POTENTIALS

Once threats are identified, project personnel shall assess the possibility of various threats to damage or otherwise undermine the ETS. The possibility can refer to skill in the case of human threats, sophistication of technical threats, and severity of natural threats. In addition to estimating the possibility of a threat, personnel shall also attempt to assess the probability of the threat occurring. Important factors to consider are the possible motivation of the attacker and the perceived value of the target system. For example, it is highly unlikely that an attacker would launch a highly sophisticated technical attack requiring national technical assets against a target system with no substantial financial or national security value.

5.3 VULNERABILITY ASSESSMENT

Vulnerability assessment identifies the consequences to the system from a specific threat, should that threat occur, and predicts the impact to the ACCMA.

5.3.1 IDENTIFICATION

Once threats are identified via threat analysis, system vulnerabilities to those threats must be determined. These vulnerabilities are often comprised of a first and second order effect. The first order effect is the immediate result of a successful attack (i.e., the attacker gaining access to a valid user account via the threat of password guessing). The secondary effect is

the consequence to the system function or users (i.e., the compromised user's information being altered or stolen).

The Integrator shall create and maintain a threat management matrix that correlates a system vulnerability to specific system components (e.g., a software module). Using this matrix, engineering staff can easily identify which vulnerabilities need to be reassessed as software or hardware is redesigned or modified.

5.3.2 IMPACT ASSESSMENT

The Integrator shall prepare an assessment of the impact to the ETS and/or the business operations that rely on the system in the event that a vulnerability is exploited by a threat. These impact assessments shall include, at a minimum, interruptions to the system services provided by the ACCMA, potential civil liabilities incurred as a result of the vulnerabilities, regulatory and/or statutory failures, and the impact to operating budgets.

5.3.3 RISK ANALYSIS

The final stage of vulnerability assessment shall weigh the vulnerabilities identified based on the threat probability and impact assessment. This assessment will be conducted by the entire EL Team. The goal is to provide a prioritized list of potential vulnerabilities. Vulnerabilities that are the result of high probability threats having significant impacts to the EL Project operation and/or public safety should be weighted more heavily.

Once the vulnerabilities are ranked, Integrator staff should incorporate additional system requirements into the trace matrix that address the threats and vulnerabilities that present potential risks to the ETS.

5.4 COUNTERMEASURE DESIGN

The final basic activity under the security engineering process is the design of the countermeasures within the software that address the vulnerabilities to the identified threats. This work will be performed by the Integrator software engineers.

5.4.1 SECURITY ARCHITECTURE

Successfully integrating security engineering into the I-580 EB EL Project will require the Integrator to adopt security architecture. The security architecture will provide structure and cohesiveness to a security design, in the same manner that software and hardware architectures are necessary to organize the design and implementation of the respective engineering solutions.

Security architectures are typically constructed around security guidelines or policies. These guidelines and policies are often derived from an underlying formal security model, although many are merely expressions of security strategy based upon empirical data (i.e., best practices information) rather than a rigid mathematical model. Whatever the genesis, security guidelines/policies are necessary to provide guidance to the software engineer(s) developing the security design.

5.4.2 CANDIDATE TRADE STUDIES

Once the architecture is defined, the Integrator shall identify candidate solutions to address specific vulnerabilities. These solutions shall conform to the security policies and

architecture. This phase of the security engineering process is similar to any other engineering design trade study.

It is important to consider not only the capability of a candidate countermeasure to address the vulnerability, but any potential side effects on system operation as a result of the security design. It is easy to adopt invasive countermeasures that effectively address vulnerabilities, but also unacceptably impact normal system operation. Security engineering is, like any other engineering discipline, a compromise between technical function, affordability and mission. The Integrator shall incorporate into the ETS the selected countermeasure designs into the software and hardware requirements where applicable.

5.5 SECURITY VERIFICATION AND TESTING

Comprehensive and accurate testing of a design is necessary to ensure that it is robust. Verification and testing of a security design is typically separated into two activity types referred to as assurance and evaluation. Assurance is the process of determining whether the system will function as designed, and evaluation is the process of proving it to others.

5.5.1 ASSURANCE

Security assurance is a process consisting of the traditional engineering techniques of analysis, inspection, and testing to verify that the EL ETS is secure. By integrating security requirements into the system, and component requirements and specifications as presented throughout this plan, ACCMA and consultant staff will confirm that the Integrator has taken all appropriate steps that are identified in the Data Security Plan. (See Verification Plan.)

5.5.2 EVALUATION

ACCMA and their consultations will perform the security evaluation. Relying party evaluation uses the current system engineering staff to define and accept the results of the testing program. In the case of the EL Project, the relying party would be the ACCMA and its consultant representatives. The organization responsible for conducting and reviewing the testing would be the ACCMA's ED and the consultants.

In cases where part, or all, of the system security requirements are dictated by other state or federal agencies, the relying organization may be the agency that created the requirements or that is charged with administering the regulations. This form of evaluation will be planned and conducted similarly to system-level acceptance testing.

Third party evaluations are performed by third party organizations with no financial or operational interest in the outcome of the evaluation testing. These evaluations can also involve certification, also referred to as accreditation, by the third party to previously established standards or processes. This aspect of evaluation is addressed in the following section.

It is recommended that the ACCMA develop security engineering guidelines and evaluation criteria for the I-580 EB EL Project since this project includes the following characteristics:

- The I-580 EB EL Project provides direct public electronic access, either via the Internet or by dedicated devices/protocols (i.e., FasTrak);

- This Project will connect to other regional toll facilities or state/federal systems via public infrastructure (i.e., the Internet, wireless communication, etc.); and

- The I-580 EB EL Project will connect to external systems that, in turn, offer public access.

Furthermore, ACCMA staff should work towards mandating evaluation guidelines for the I-580 EB EL Project to be used as the basis for all future EL projects that are under the jurisdiction of the ACCMA in the region and that are interconnected with other internal or external tolling and information systems or devices.

D. CONFIGURATION MANAGEMENT PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

CONFIGURATION MANAGEMENT PLAN GUIDELINES

PLAN GUIDELINE SECTIONS:

1. **GENERAL**
2. **ROLES AND RESPONSIBILITIES**
3. **CONFIGURATION MANAGEMENT PLAN COMPONENTS**
4. **CONFIGURATION IDENTIFICATION**
5. **CONFIGURATION MANAGEMENT CHANGE CONTROL**
6. **STATUS ACCOUNTING**
7. **CONFIGURATION AUDITS**
8. **INTERFACE CONTROLS**
9. **INTEGRATOR MANAGEMENT**

1. GENERAL

The primary purpose of the Configuration Management Plan (CMP) guidelines is to establish and maintain the integrity and control of software/hardware products and documents supplied by the Integrator during the development life cycle of an Intelligent Transportation System and its' operation and maintenance.

The CMP for the I-580 EB EL ETS contract will address the management and control of content, change, and status of shared information within the ETS development and implementation. This includes products such as performance requirements, functional and physical requirements, and design and operation information.

The CMP shall identify both technical and administrative direction for the control of change and integrity of the ETS product data and documentation. The CMP shall identify the configuration of the software and hardware, including commercially-off-the-shelf (COTS) products, at given points in time, systematically controlling changes to the configuration, and maintaining the integrity and traceability of the configuration throughout the project's life cycle.

2. ROLES AND RESPONSIBILITIES

The EL CMP for the project implementation stage shall follow the configuration management guidelines presented in this document. The CMP shall be developed by the selected Integrator during the early part of the system design phase.

Listed below are suggested starting points for defining organizational responsibilities pertaining to the Configuration Management (CM) activities required to ensure program success.

2.1 ALAMEDA COUNTY CONGESTION MANAGEMENT AGENCY (ACCMA)

The ACCMA ED shall have full contractual responsibility for all EL configuration management activities and will work closely with the consultant staff to ensure that configuration management during the overall design, development, testing, installation, and deployment of the system. Configuration management will enable successful project completion and efficient ongoing support and maintenance for the duration of the EL Project. The ACCMA shall have final approval of the CMP.

2.2 PROJECT CONSULTANT STAFF

The ACCMA's EL consultants will have the following roles and responsibilities:

- Review the CMP developed by the Integrator for completeness and compliancy with the functional requirements presented in the Request for Proposal (RFP) and other contract documents.
- Audit the CM process that has been developed by the Integrator to ensure that the process is correct and that there are built-in control mechanisms that will lead to a successful project.
- Establish a specific hierarchy of information for both project non-deliverables and deliverables.
- Create a CM process to support change evolution of the ETS software and hardware.
- Monitor the ETS application system delivery and release management procedures that shall be developed by the Integrator

2.3 INTEGRATOR SYSTEMS ENGINEER(S)

The Integrator engineering personnel for the EL Project shall have the following roles and responsibilities:

- Develop a comprehensive CMP for the EL project ETS design, build and deployment phases.
- Identify and document the functional and physical characteristics of the system, software, hardware, and operational components so that these relationships may be managed, maintained, controlled, and assured.

- Record and report the status of proposed changes consistent with the established CM process, approval of any proposed changes and the status of the implementation of approved changes.
- Disseminate baseline information to the project management (ACCMA/Consultant) personnel, and establish and maintain a status accounting and reporting system that records the baseline, authorized changes to the baseline, and verification of changes incorporated into the documentation and/or product.

3. CONFIGURATION MANAGEMENT PLAN COMPONENTS

The Software/Hardware Configuration Management Plan for the EL ETS project shall contain the following integrated activities, as reflected below in Figure 1.

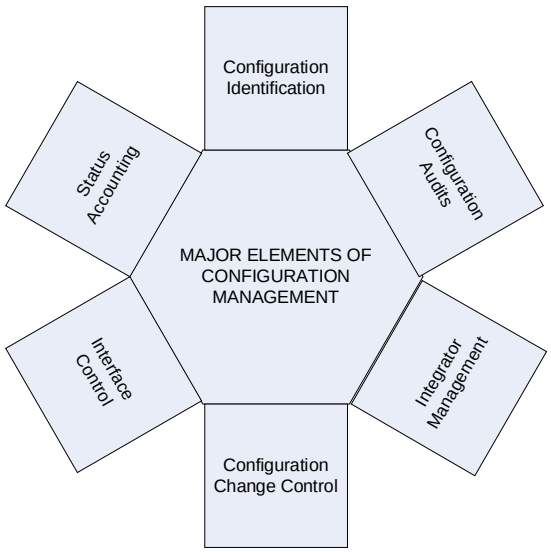


Figure 1 - Configuration Management Plan Elements

Presented bellow is a description of each of the CMP elements that shall be developed and adhered to by the Integrator:

- **Configuration Identification** of work products that shall be developed and utilized by the Integrator.
- **Configuration Change Control** of information, including the impact of changes to ETS application development tasks, management schedules, budgets, technical or

quality assurance activities, testing or retest requirements, and project status reporting mechanisms.

- **Status Accounting** of work products developed and used by the Integrator during the design, development, integration, testing, deployment, operations, and maintenance of the ETS application system.
- **Configuration Audits** that assess the status and acceptability of products controlled or released by the Integrator.
- **Interface Control** process to manage all external interface integrity and control procedures.
- **Integrator Management** to monitor ETS application system delivery and release management procedures.

The Integrator shall perform the work associated with these components that are consistent with the complexity of the EL ETS.

4. CONFIGURATION IDENTIFICATION

The configuration identification component of the EL ETS CMP shall specify what information has been approved for concurrent use on the project, who owns the information, how the information was approved for CM control, and what the latest approved release of the component is. The Configuration Identification elements are presented below in Figure 2.

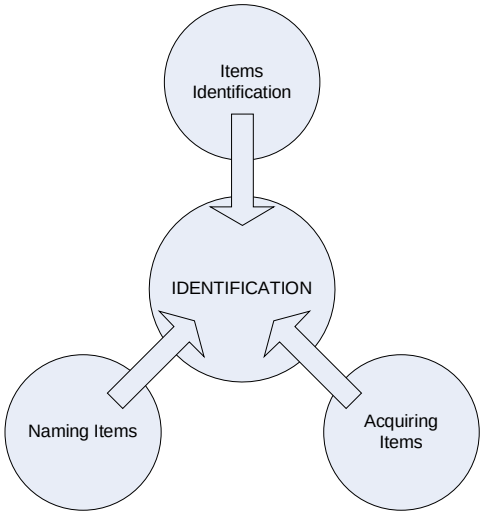


Figure 2 – Configuration Identification Elements

4.1 CONFIGURATION ITEM IDENTIFICATION

The CMP shall record the items to be controlled, the project Configurable Items (CIs), and their definitions as they evolve. The CMP shall also describe how the list of items and the structures are to be maintained for the project. At a minimum, all CIs that are to be delivered shall be listed.

Appropriate baselines shall be defined at control points within the project life cycle in terms of the following:

1. The event that creates the baseline;
2. The items that are to be controlled in the baseline;
3. The procedures used to establish and change the baseline; and
4. The authority required to approve changes to the approved baseline documents.

A means of identifying changes and associating them with the affected CIs and the related baseline shall be specified.

4.2 NAMING CONFIGURATION ITEMS

The CMP shall specify an identification system to assign unique identifiers to each CI. It shall also specify how different versions of each are to be uniquely identified. Identification methods shall include naming conventions and version numbers and letters.

The CMP shall describe the methods for naming controlled items for purposes of storage, retrieval, tracking, reproduction, and distribution. Activities may include version marking, labeling documentation and executable software, serialization, and altered item marking for executable code.

COTS software, vendor proprietary software, and support software may require special identification schemes and labeling.

4.3 ACQUIRING CONFIGURATION ITEMS

The CMP for the ETS project shall identify the controlled software libraries for the project and describe how the code, documentation, and data of the identified baselines are to be physically placed under control in the appropriate library. For each library the format, location, documentation requirements, receiving and inspection requirements, and access control procedures shall be specified.

Based on the RFP and other Contract requirements, the CMP shall specify procedures for the actual storage of documents and magnetic media, including the identification of software/hardware items. Data retention periods and disaster prevention and recovery procedures, which will be identified in the RFP, shall also be described.

Procedures shall describe how to retrieve and reproduce controlled items from library storage. These activities include verifying labeling, tracking controlled copies, and protecting proprietary and security information.

5. CONFIGURATION MANAGEMENT CHANGE CONTROL

The CMP shall define the configuration control process and procedures designating the level of control through which each software /hardware work product must pass (for example, author control, project-level control, acquirer control); identifying the persons or groups with authority to make changes at each level (for example, the programmer/analyst, the software/hardware lead, the project manager, the acquirer); and the steps to be followed to obtain required authorization for changes, to process change requests, to track changes, to distribute changes, and to maintain past versions.

The Integrator's internal software modification control procedures that shall be used in support of the ETS software/hardware development and testing efforts shall be identified in the CMP. The CMP shall also include the various Integrator internal and external interface processes and procedures.

For each project software/hardware components of the ETS solution, the CMP shall describe the change controls imposed on the baseline CIs. The CMP shall identify the following sequence of configuration control specific steps when a change is required:

1. Request a change;
2. Evaluate the change request;
3. Approve or disapprove the request; and
4. Implement the change.

Presented below, in Figure 3, are the Configuration Control steps that shall be followed by the Integrator:

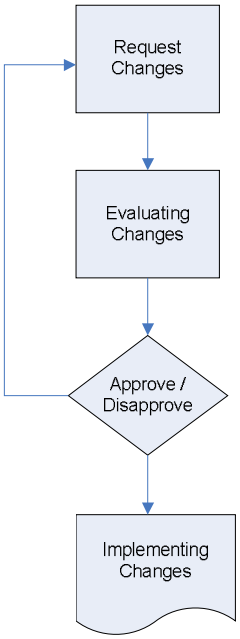


Figure 3 - Configuration Control Process

The CMP shall identify the records to be used for tracking and documenting this sequence of steps for each change. Any differences in handling changes based on the origin of the request shall be explicitly documented.

5.1 REQUESTING CHANGES

The CMP shall specify the procedures for requesting a change to a baseline CI and the information to be documented for the request. At a minimum, the information recorded for a proposed change shall contain the following:

- The name(s) and version(s) of the CIs for which a change is proposed;
- Originator's name and organization;
- Date of request;
- Indication of urgency;
- The need for the change; and
- Description of the requested change.

Additional information, such as priority or classification, must be included to clarify the significance of the request and to assist in its analysis and evaluation. Other information,

such as change request number, status, and disposition, shall be recorded for change tracking.

5.2 EVALUATING CHANGES

The CMP shall specify the analysis required to determine the impact of the proposed change and the procedures for reviewing the results of the analysis. Changes should be evaluated to determine their effect on the deliverable, their impact on cost, project resources and potential impact on project schedule.

5.3 APPROVE OR DISAPPROVE CHANGES

The ACCMA ED, or their designee, shall serve as the configuration control person responsible for the approval or disapproval of the proposed changes. The ED shall document the decision, in writing, reflecting any changes to the Integrator's scope of work regardless of whether it impacts the budget or schedule of the EL Project.

5.4 IMPLEMENT CHANGES

The CMP shall specify the activities for verifying and implementing an approved change. The information recorded for the completion of a change shall contain the following at a minimum:

- The change request(s);
- The names and versions of the affected items;
- Verification date and responsible party;
- Release or installation date and responsible party; and
- The identification of the new version.

Additional information, such as software fault metrics or identification of the supporting software used to implement the change, may be included.

The CMP may also specify activities for release planning and control, for example coordinating multiple changes, reconfiguring the CIs, and delivering a new baseline.

6. STATUS ACCOUNTING

The CMP shall define status accounting activities which record and report the status of ETS system CIs.

The Plan shall include, as a minimum, the following:

- What data elements are to be tracked and reported for baselines and changes;
- What types of status accounting reports are to be generated and their frequency;
- How information is to be collected, stored, processed, and reported;
- How access to the status data is to be controlled; and
- If an automated system is used for any status accounting activity, its function shall be described or referenced.

The following minimum data elements shall be tracked and reported for each CI:

- Its initial approved version;
- The status of requested changes; and
- Implementation status of approved changes.

7. CONFIGURATION AUDITS

The CMP shall identify the ETS system implementation configuration audits that shall determine to what extent the actual software/hardware configuration items reflect the required physical and functional characteristics. Configuration reviews are management tools for establishing a baseline.

The CMP shall identify the configuration audits and reviews to be conducted on the project. At a minimum, a configuration audit shall be performed on all the software/hardware configuration items prior to its release.

For each planned configuration audit or review, the CMP shall define the following:

- The objective of the audit;
- The software/ hardware CIs under audit or review;
- The schedule of audit or review tasks;
- The procedures for conducting the audit or review;
- The audit participants by job title;
- The documentation required to be available for review or to support the audit or review;
- The procedure for recording any discrepancies and reporting of corrective actions; and
- The approval criteria and the specific action(s) to occur upon approval.

8. INTERFACE CONTROLS

The CMP shall identify the Interface Control (IC) activities to support external interfaces to BATA and other entities within the EL end to end solution. The IC activities shall coordinate changes to the interfacing items outside the scope of the ETS system CIs. Hardware, system software and support software, as well as other components and deliverables, should be examined for potential interfacing effects on the overall project.

The CMP shall identify the external items to which the project software/hardware interfaces. For each interface the CMP shall define, as a minimum, the following:

- The nature of the interface;
- The affected organizations;

- How the interface code, documentation, and data are to be controlled; and
- How the interface control documents are approved and released into a specified baseline.

9. INTEGRATOR MANAGEMENT

Integrator control activities described herein ensure that items developed for the ETS for the overall EL Project CIs meet the requirements of the RFP and the Contract documents and approved changes.

For both Integrator furnished and COTS software or hardware, the CMP shall define the activities to incorporate these items into the EL Project. For Integrator supplied software/hardware, the CMP shall describe, at a minimum, the following:

- What ETS requirements, including the system implementation plan, are to be part of the Integrator agreement;
- How the Integrator will be monitored for compliance;
- What configuration audits and reviews of Integrator items will be held;
- How external code, documentation, and data will be tested, verified, accepted, and merged with the overall project;
- How proprietary items will be handled for security of information and traceability of ownership (e.g., copyright and royalties); and
- How changes are to be processed, including the Integrator participation.

For COTS software, the CMP shall describe how the software will be received, tested, and placed under ETS Integrator control, how changes to these items will be processed, and how the Integrator will participate in the EL project change management process.

E. SYSTEM INTEGRATION PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

SYSTEM INTEGRATION PLAN GUIDELINES

PLAN GUIDELINE SECTIONS:

1. **GENERAL**
2. **ROLES AND RESPONSIBILITIES**
3. **SYSTEM INTEGRATION TASKS**
4. **INTEGRATION PLAN COMPONENTS**
5. **INTEGRATION SUPPORT**

1. GENERAL

This document presents the ETS equipment and System Integration Plan (Integration Plan) guidelines. The Integration Plan shall define the activities necessary to integrate the components of the ETS to meet the functional and performance requirements in hardware and or software.

The Integration Plan shall contain an overview of the system, a description of the major tasks involved in the integration, including the resources that are needed to fully support the integration effort.

The Integration Plan shall be developed by the selected System Integrator during the system design and development phase and should be updated prior to being used during the Integration and Test Phase. The final version would be provided in the Implementation Phase for approval by the ACCMA. The Integration Plan shall outline the different types of integration tests conducted to ensure that the ETS is designed and operates according to the RFP, approved design and the other Contract documents. The Integration Plan shall also identify the roles and responsibilities of each Integrator development group that will be working on this project.

2. ROLES AND RESPONSIBILITIES

To ensure that the delivered ETS operates according to the RFP, approved design and the other Contract document requirements, functional positions of the system engineering and development organization will have specific roles and responsibilities. Listed below are suggested starting points for defining organizational responsibilities, including the management and oversight, pertaining to the system integration activities required to ensure program success.

2.1 ACCMA PERSONNEL

The ACCMA ED shall have full contractual responsibility for all EL equipment and system integration activities, and will work closely with the consultant staff to ensure that the ETS integration is accomplished properly. The ACCMA shall review and approve the Integration Plan prior to use by the Integrator.

2.2 PROJECT CONSULTANT STAFF

The EL tolling system consultant staff shall have the following roles and responsibilities:

1. Review and provide comments on the Integration Plan and all ETS integration methods, test plans and procedures, schedule, policies and validation procedures for the EL Project. It should be noted that the referenced tests are not the software developer's internal unit, configuration item and integration tests which must precede the EL subsystem and system tests. Furthermore, independent tests will be performed by the ACCMA as identified in the Verification (Test) Plan.
2. Participate in all facets of integration activities and provide recommendations to the ACCMA for verification testing during integration stages of the project.
3. Provide technical assistance to the Integrator and ACCMA staff during the integration process.
4. Provide guidance, in conjunction with the ACCMA management staff, during integration testing with live traffic inputs and other stimulus to stress test the System and demonstrate performance under unusual events. .
5. Maintain a liaison with ACCMA and Integrator staff to incorporate additional Integration testing procedures and additional operational scenario management based on external requirements.

2.3 INTEGRATOR SYSTEMS ENGINEERING STAFF

The Integrator's system engineering and development personnel for the I-580 EB EL Project shall have the following roles and responsibilities:

1. Develop a comprehensive Integration Plan to effectively support the EL ETS. The Integration Plan shall be submitted for approval by the ACCMA.
2. Perform all Integration tests described in the plan including demonstration of functional and performance requirements, and explaining to the ACCMA/consultant group each procedure that is being conducted and the requirement(s) the procedure is expected to satisfy or demonstrate compliance.
3. Ensure that subsystem and end-to-end system integration testing satisfy all RFP and design requirements by utilizing a trace matrix.
4. Develop a detailed integration report documenting all integration tests that were run, any failures and deficiencies that were uncovered, and how those failures and deficiencies would be corrected. All software modifications will require

regression testing before releasing a new version through a formal configuration management process.

5. Perform any required re-integration activities identified by ACCMA and consultant staff. Re-integration documentation shall be submitted to the ACCMA.

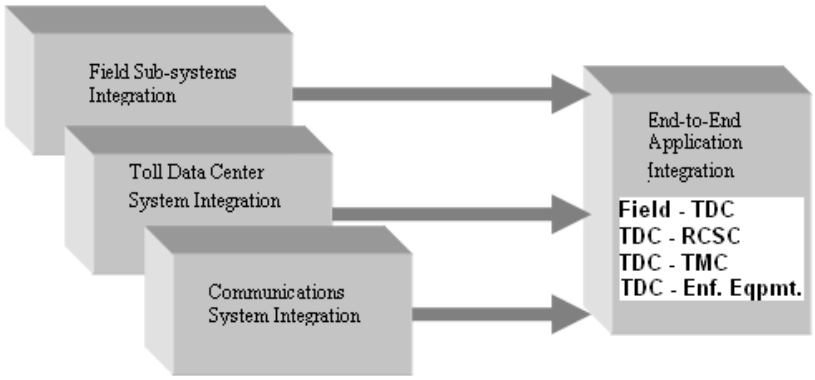
3. SYSTEM INTEGRATION TASKS

The EL ETS Integration Plan shall detail a task-based integration process that will accommodate the various sub-systems of the ETS.

The System Integration Plan shall clearly describe the following phases:

- Task 1 - Field Subsystems Integration;
- Task 2 – TDC Subsystem Integration;
- Task 3 - Communications Subsystem Integration (nodes and local carrier); and
- Task 4 – End-to-End System Integration (field - TDC, TDC - RCSC and TDC - TMC).

Presented below in Figure 1 is a schematic that shows the distinct EL Project ETS integration phases and how each phase relates with one another.



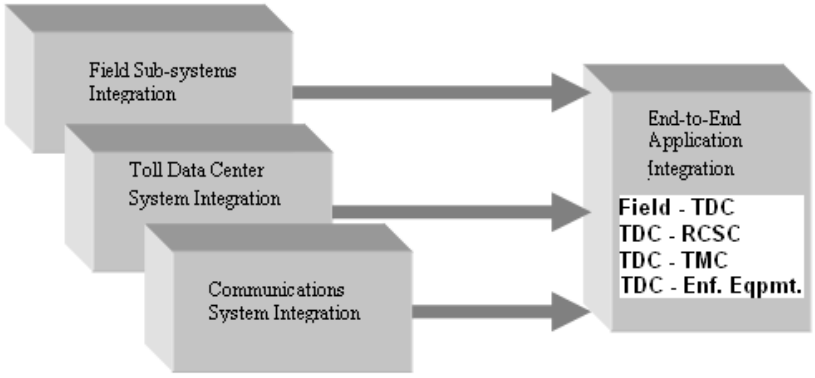


Figure 1 – Integration Process

3.1 FIELD SUB-SYSTEMS INTEGRATION

The Integration Plan shall define in detail the integration of each of the field sub-systems of the EL tolling solution. This would include, at a minimum:

1. The electronic tolling system;
2. The Dynamic Message Sign (DMS) system;
3. The Vehicle Detection Station (VDS) system;
4. The EL enforcement system; and
5. The Closed Circuit Television (CCTV) system.

The Integrator sub-system integration tests should include, at a minimum, the following test environments to satisfy the functional and performance requirements in the RFP, approved design and other Contract documents:

- Verify data integrity (no loss of data and guaranteed receipt of data);
- Introduce all possible failures (individually and in groups) and measure performance to identify and document critical failures;
- Introduce degraded mode performance and measure all functional and performance impacts;
- Verify robustness of access security;
- Verify VDS and reader input and data processing;
- Verify Transaction Beacon and HOV status CMS (future capability) output:
- Verify accurate downloads and storage of tag status list and updates, configuration files, system timing, security access tables

- Verify existence and accuracy of diagnostic messages for failures and degradations; and
- Validate maintenance and transaction records and real time transmission to TDC.
- Confirm accuracy and completeness of data written to System logs.

3.2 TOLL DATA CENTER SYSTEM INTEGRATION

The Integration Plan shall define in detail the integration of each component/peripheral comprising the TDC subsystem of the EL ETS solution. This would include, at a minimum;

- Customer Service Representative (CSR) workstations;
- Management workstations;
- Real Time monitoring (including CCTV video) workstation;
- Dynamic pricing application server;
- ETS applications server;
- ETS Transaction Processing/Database server;
- ACCMA Web site server, RCSC gateway and firewall;
- Network/Mail server;
- Interface to the Caltrans TMC;
- Interface to the BATA RCSC;
- Interface to DMS (i.e., pricing sign)
- Interface to the EL enforcement equipment;
- Network switch, router, and CSU/DSU (T1 interconnection); and
- Network printers.

The System Integrator shall develop and document tests to verify the following required capabilities in the Integration Plan:

- Diagnostic results;
- Transaction and trip records for every user with a valid and properly mounted transponder traveling in the EL;
- No transaction and trip records for every user with a valid and properly mounted transponder traveling in a general purpose (GP) lane;
- Traffic data received by TDC at configurable time periods from the EL and each GP lane at every location with VDS installed;
- DMS pricing display consistent with maintaining traffic at LOS C under normal operating conditions and LOS D during high user demand;
- DMS pricing display when communication with TDC is lost;
- Transmission of trip records from TDC to the BATA RCSC;
- Transmission of tag status list and updates from TDC to the BATA RCSC;
- Transmission of traffic data and roadway surveillance video (including camera control signals) from TDC to the Caltrans TMC;

- Transmission of DMS messages from Caltrans TMC to TDC;
- Activation of transaction beacon for every user with a valid and properly mounted transponder traveling in the EL;
- Transmission at configurable time periods of tag status list and updates from TDC to mobile and portable enforcement equipment;
- Successful read (including any stored transaction data) and display/indication of every valid and properly mounted transponder traveling it the EL by the mobile enforcement reader;
- Successful read (including any stored transaction data) and display/indication of every valid transponder by a portable reader; and
- Proper association of vehicle and valid and properly mounted transponder.

3.3 COMMUNICATIONS SYSTEM INTEGRATION

The Integration Plan shall define in detail the full integration of the entire communications subsystem in support of the EL solution. This would include, at a minimum:

- TDC and roadside communication gear supporting landline and wireless communication links, as applicable;
- Common carrier leased line and wireless communications
- Redundant communications between TDC and tolling zone;
- Redundant communications between TDC and VDSs (either direct or via toll zone roadside communications);
- Communications between TDC and DMS (i.e., pricing sign)
- Communications between TDC and BATA RCSC;
- Communications between TDC and Caltrans TMC; and
- Communications between TDC and enforcement equipment.

The following communication subsystem installation/integration tests performed by the System Integrator should be described in the Integration Plan:

- OTDR and power metering testing of all fiber optic lines (including on-reel and installed and terminated state);
- Wireless Communication Tester used to assess quality of wireless equipment and devices;
- Communications data throughput tests;
- Communications error handling tests; and
- Communications failover and recovery tests demonstrating redundancy and reliability for both wireless and landline environments where redundant links are deployed.

3.4 END-TO-END APPLICATION INTEGRATION

The Integration Plan shall define in detail the integration of each subsystem forming an accurate and reliable end-to-end EL solution. The plan shall detail each of the tests that would verify and validate the integration of all subsystems to successfully meet all approved design and contractual requirements, including the following:

- Required inputs to and outputs from the TDC that is configured to include a dynamic pricing algorithm, a trip generation process, a maintenance module and a transaction processor;
- Interface to the Caltrans TMC; and
- Interface to the BATA RCSC.

4. INTEGRATION PLAN COMPONENTS

The basic Integration Plan developed by the Integrator shall contain a series of activities to be executed as part of the System Integration tasks.

Integration testing activities and scenarios shall include complete end-to-end testing of all required functions and capabilities of the System. This integration testing will involve using live traffic at the Integrator's production facility. Additional testing will be conducted with live traffic while the HOV lane is operational as an HOV/MF lane. It will not be opened to EL traffic until all testing is successfully completed.

4.1 INTEGRATION ACTIVITIES

The following System Integration activities need to be addressed in the Integration Plan to support the associated integration tests and provide a comprehensive review and audit of the ETS integration:

1. Provide overall planning and coordination for Integrator activities needed to successfully integrate the ETS;
2. Provide appropriate training for personnel to carry out the integration tasks;
3. Provide appropriate documentation on each subsystem for integration;
4. Provide review and audit reports;
5. Document subsystem software configuration items and database design;
6. Establish integration test procedures;
7. Document all subsystem and System integration test results, including any hardware/equipment failures during field tests; and
8. Replace defective hardware/equipment and or identify software deficiencies, modify configuration item, integrate, perform regression testing (as applicable), release new version and retest System.

The ACCMA and their representatives shall be permitted to participate in or otherwise observe any and all of these Integration Tasks. The Integrator shall develop an integration schedule for when these tasks are expected to be completed. Tentative milestone dates and days after predecessor tasks and before successor tasks for conducting the various integration phases, shall be included in the Integration Plan document submitted by the

Integrator during the system design phase of the Contract. Reasonable modifications to these dates may be permitted during the course of the work by the ACCMA provided a written request for such change that includes a revised schedule, which is made at least two weeks prior to the revised Integration Phase test date giving rise to the change. The actual change approval must be granted, in writing, by the ACCMA.

4.2 STEPS RELATED TO ACTIVITIES

This section of the Integration Plan shall provide a detailed description of each major Integrator step required for the full integration of the ETS. The following information shall be included in the description of each major step, as appropriate:

1. What the step is expected to accomplish;
2. Resources and conditions required to accomplish the step;
3. Key person(s) responsible for the step; and
4. Release version(s) and or part number(s) involved in the step;
5. Criteria for determining successful completion of the step

Step Accomplishment
This element of the Integration Plan shall describe the expected results of each of the integration step to be carried out by the Integrator.

Resource Requirements and Preconditions
This element of the Integration Plan shall contain the test bed hardware, equipment and software products, such as special test software, software drivers, and simulation data, along with environmental protection, communication interconnections, and power source that is needed to perform a particular integration test.

Key Integration Staff
This section shall identify the key system integration staff, including system engineers and programmers responsible for writing an external interface needed to enable successful integration of a subsystem or the ETS.

Products Being Tested
This section shall identify the version of the software and or the part number (corresponding to a specific detailed item) of the hardware/equipment being tested.

Criteria for Step Completion
The Integration Plan shall provide both the Integrator and the ACCMA a mechanism for verifying and documenting successful integration of all subsystems comprising the System. Satisfaction of specific requirements from a traceability matrix that are intended to be demonstrated by the test shall be listed. Testing procedures and scenarios, which will be developed by the Integrator and subject to ACCMA approval, may build upon scripts and test steps that are developed to demonstrate satisfaction of related requirements.

5. INTEGRATION SUPPORT

The Integration Plan shall describe the support software, materials, equipment, communication and power, and facilities required for the integration, as well as the personnel requirements and training necessary for System integration.

Resources and their Allocation
The plan shall list all support software, materials, equipment, and facilities required for the end-to-end EL application integration. The Integration Plan shall describe the test environment, communication and power along with any other resources needed. The Plan shall describe the number of qualified personnel and associated man-hour estimate for each labor category involved in the integration.

Training
The Integration Plan shall identify the training necessary to understand the integration process, identify the hardware and software configuration items, to audit system performance and to maintain the integrated System.

Testing
The Integration Plan shall allocate approved design and contract requirements to proposed integration tests that may involve multiple scenarios to fully demonstrate. It should include a description for each suite of integration tests, including input data required, procedures for testing, expected output, who is responsible for conducting the testing and the integration testing schedule, as addressed above. This could be accomplished in one plan or several, depending on the complexity of the suite of integration tests being tested.

Any failures or software deficiencies encountered during integration testing must be resolved and retested before commencement of the Operational Performance Test (OPT), which is described in the Verification (Test) Plan. The integration problems identified will be tracked by the Integrator and a problem matrix shall be provided to the ACCMA, if requested.

F. VERIFICATION (TEST) PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

VERIFICATION (TEST) PLAN GUIDELINES

PLAN SECTIONS:

1. **GENERAL**
2. **ROLES AND RESPONSIBILITIES**
3. **TEST PLAN**
4. **EQUIPMENT ENVIRONMENTAL TESTING**
5. **FACTORY ACCEPTANCE TEST**
6. **ON-SITE INTEGRATION AND COMMISSIONING TEST**
7. **OPERATIONAL PERFORMANCE TEST**

1. GENERAL

This document will present the EL electronic toll system (ETS) equipment and system verification testing process guidelines for the development of the Verification (Test) Plan. The Plan will outline the different types of verification tests that shall be conducted by the ACCMA and the consultants and identify the roles and responsibilities of each group. The Integrator shall also conduct various internal testing procedures throughout the course of the ETS design, development, and deployment phases of the Contract to ensure that the ETS requirements are being properly met. These internal Integrator internal tests are not specified in this Plan.

2. ROLES AND RESPONSIBILITIES

Listed below are starting points for defining organizational responsibilities pertaining to the verification test activities required to ensure program success.

2.1 ACCMA PERSONNEL

The ACCMA ED shall have full contractual responsibility for the ETS equipment and system verification testing activities, and will work closely with the Consultant staff to ensure that the testing is accomplished properly.

2.2 PROJECT CONSULTANT STAFF

The ACCMA's EL Program and tolling system consultant staff shall have the following roles and responsibilities:

1. Create and maintain all system verification and testing engineering related processes, policies and operating procedures for the EL project.
2. Participate in all facets of testing activities and provide recommendations to the ACCMA for verification testing related aspects of the project.
3. Provide technical assistance to the Integrator and ACCMA staff during the testing process.
4. Provide regulatory guidance for security-related requirements in conjunction with the ACCMA management staff.
5. Maintain a liaison with ACCMA and Integrator staff to incorporate additional testing procedures and ad hoc tests into the EL verification and testing process.

2.3 INTEGRATOR SYSTEMS ENGINEERING STAFF

The Integrator systems engineering personnel for the EL Project shall have the following roles and responsibilities:

1. Develop the various test scripts and procedures required to support the EL verification and testing process.
2. Perform the various tests required, detailing to the ACCMA/Consultant group each procedure that is being conducted and why.
3. Ensure that the various system and equipment testing requirements and processes are properly flowed down from the RFP and the Contract documents by using comprehensive requirements trace matrix.
4. Develop a detailed testing report of all the tests that were run, any problems that were discovered, and how those problems would be corrected.
5. Perform any required re-testing activities identified by ACCMA and Consultant staff.

3. TEST PLAN

The Integrator shall prepare a detailed Verification (Test) Plan (Test Plan) for testing all hardware, software and the full integration of the EL System. The Test Plan shall be developed to confirm that the various system functional requirements that are presented in the RFP, the system design documentation and the other Contract documents are met by the equipment and/or system operations. The Test Plan and subsequent testing activities shall be developed and executed for four (4) distinct phases. Each test phase shall commence only upon the successful completion of the previous phase. The four (4) test phases that will be conducted by the Integrator, in the following order, are presented below:

1. Equipment Environmental Testing;
2. Factory Acceptance Test (FAT);
3. On-site Integration and Commissioning Test; and

4. Operational Performance Test.

The Integrator shall be responsible to develop comprehensive test scripts and test plans to ensure that the system development meets all of the system requirements presented in the EL ETS RFP and the other Contract documents. The test scripts and plans will be reviewed and approved by the ED in collaboration with the consultants. The test scripts and plans shall be closely adhered to during each phase of equipment and system testing. At the completion of each test, the Integrator shall submit final test results to the ACCMA for final approval. The ED, based upon consultant personnel recommendations, will approve the test results.

Presented below in Figure 1 is a schematic that shows the four (4) distinct EL Program testing phases and how each phase inter-relates with the others.

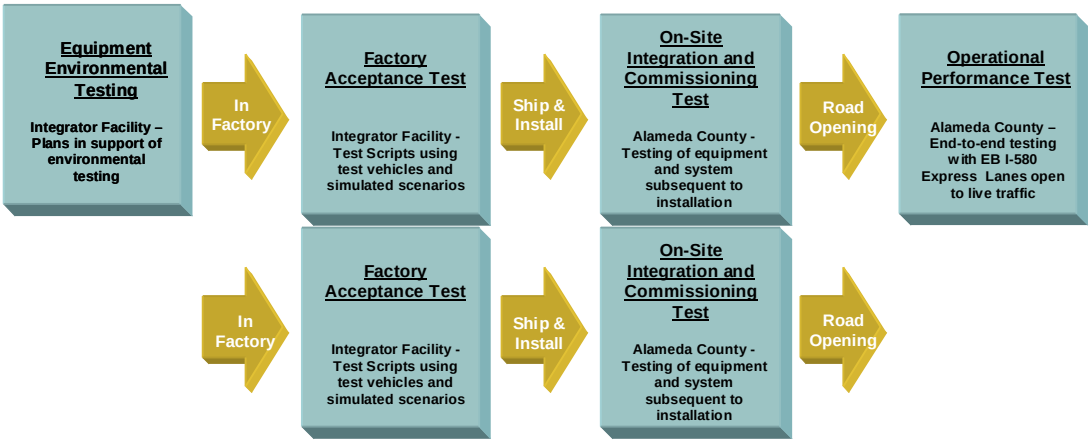


Figure 1 – Testing Process

The ACCMA and their representatives will be permitted to participate in or otherwise observe any and all of these tests at the ACCMA's sole discretion. Tentative dates for conducting the various tests shall be included in the Test Plan document that shall be submitted by the Integrator during the system design phase of the Contract. Reasonable modifications to these dates may be permitted during the course of the work by the ACCMA provided a written request for such change is made at least two weeks prior to the revised test date. The actual change approval must be granted, in writing, by the ACCMA.

4. EQUIPMENT ENVIRONMENTAL TESTING

As a preliminary effort to factory acceptance testing, the Integrator shall also provide test results, certified by a testing laboratory approved by the ACCMA, confirming that all proposed system equipment that is to be installed is suitable to operate within its proposed environment. If certified test results are not available, the results do not meet the RFP requirements, or they are not satisfactory to the ACCMA, the Integrator shall arrange for

such tests to be conducted or re-conducted at no additional cost to the ACCMA. The Integrator shall provide the ACCMA with certified test results for all equipment that is to be installed outdoors, or in any other non-environmentally controlled location. For equipment that is to be installed inside a building, cut sheets showing environmental operating requirements will be acceptable.

5. FACTORY ACCEPTANCE TEST (FAT)

The intent of the FAT, which will be held at the Integrator's system development office, is to allow the Integrator to conclusively represent that the EL equipment, subsystems and overall system comply with the system functional requirements. Representatives from the ACCMA, the consultant group, and possibly the BATA and/or Caltrans are expected to be present at the FAT. The FAT shall be successfully completed, and accepted by the ACCMA, prior to commencement of on-site equipment installation, system integration, and field testing. Equipment and/or system failures encountered during the FAT shall be resolved, retested, and acknowledged as being resolved by the ACCMA prior to issuance of FAT approval to the Integrator.

The Integrator shall prepare detailed test scripts that will be used as the basis for the FAT. FAT Scripts shall cover test set-up, step-by-step procedures and pre-determined expected results. FAT scripts shall be submitted and approved by the ACCMA prior to the commencement of the FAT. FAT scripts shall be submitted for review and approval at least 60 days prior to scheduling the factory test.

Components used in the FAT shall be production models, which would otherwise be suitable for installation in the EL System. Testing and careful evaluation of samples and prototypes shall be completed prior to the commencement of the FAT.

It is possible that certain components of the overall EL System may not be available during factory testing. The Test Plan shall indicate those portions or components that will not be available during the FAT. Where applicable, the Integrator shall attempt to simulate the missing components to represent a fully functioning system.

The FAT is the culmination of the design, development, fabrication, and pre-test of the EL System equipment, subsystems, and overall system. The FAT shall be performed by the Integrator under the supervision of, and with the participation of, the ACCMA. The FAT shall be witnessed by the ACCMA and the other groups referenced above, with acknowledgment of scenario success and/or failure by the ACCMA.

The following are recommended features of the EL System that are, at a minimum, to be demonstrated during the FAT:

- Equipment power up tests;
- Verify initialization;
- Verify data integrity (no loss of data);
- Verify diagnostic messages;
- Introduce failures and threats;
- Degraded mode performance;

- Verify diagnostic messages;
- Normal transaction tests;
- Tolling zone operational tests;
- Proper association of vehicle and transponder;
- Tolling zone stand-alone tests;
- Operation of the TDC, including the dynamic pricing algorithms and the trip generation process;
- Interface to the Caltrans TMC;
- Integration between the TDC and the BATA RCSC;
- Communication link between the tolling zones and the TDC;
- Generation of traffic, toll revenue and reconciliation reports;
- Data analysis;
- Integrity checking;
- System audit; and
- Others yet to be identified.

6. ON-SITE INTEGRATION AND COMMISSIONING TEST

The On-site Integration and Commissioning Test (OICT) shall include equipment, subsystem, and system-wide testing of the ETS. The purpose of the OICT is to provide both the Integrator and the ACCMA with a mechanism for verifying and documenting successful system performance throughout the installation process up to the point of approval to open the EL to toll-paying vehicles. Testing procedures and scenarios, which will be developed by the Integrator and will be subject to ACCMA approval, shall be built on the previous FAT scripts and test steps.

The Integrator shall prepare detailed test scripts for the OICT. OICT scripts shall be designed to verify the equipment installation and confirm that the subsystem and/or component(s) are ready for operation on the EL System, and the Commissioning Test can then begin.

The tests to be performed shall be defined in the Integrator's Test Plan and test scripts. The detailed test scripts and scenarios of the Test Plan shall be submitted and approved by the ACCMA prior to commencement of any of the specific tests. Performance of the various tests shall be witnessed by the ACCMA with acknowledgment of scenario successes, failures, or potential system or equipment threats.

At the subsystem and component level(s), the OICT shall cover installation check-out and performance verification at each applicable location throughout the EL System. At the system wide level, the OICT shall also cover end-to-end testing that represents a fully integrated and functional EL System with all subsystems and components successfully integrated on-site. The intent of end-to-end testing during the OICT phase is to ensure readiness for the subsequent Commissioning Test.

The commissioning portion of the OICT will be conducted in order to represent the operational readiness of the system prior to deployment. Testing activities and scenarios during these tests shall include complete end-to-end testing of all functions and operations

of the EL System. This testing will involve live traffic in the EL, both real traffic and test vehicles. To ensure that all of the stated RFP and Contract operating requirements are effectively met, the Integrator will submit the comprehensive requirements trace matrix and confirm, in writing to the ACCMA, that the tolling system has met each and every stated requirement.

Any failures encountered during the Commissioning Test must be resolved, retested, and acknowledged by the ACCMA before opening of the EL to traffic and the launch the of the Operational Performance Test (OPT). The tests shall be similar to the tests in the FAT and shall be conducted under the supervision of, and with the participation of, the ACCMA and their representatives, in accordance with the test plan and test scripts previously approved. Testing results and corresponding documentation regarding the completion of the OICT shall be submitted to the ACCMA for approval. The OICT must be approved before beginning the Commissioning Test.

7. OPERATIONAL PERFORMANCE TEST

The final phase of testing of the EL System is the OPT. This test shall closely monitor the performance of the EL under live traffic operating conditions, once the EL is open to toll-paying vehicles. Activities during this period of testing will include all necessary scripted test documentation, unscripted ad-hoc tests as well as monitoring day-to-day functions of the EL System, including the operation of the equipment at the three tolling zones, the operation of the TDC, trip building functionality at the TDC, the behavior of the toll rate setting algorithm, the interface to the BATA RCSC, interface to the enforcement equipment/software, etc.

The OPT shall be conducted over a 30-day continuous period without degradation in performance or failure in compliance with contract system requirements. Throughout the 30-day test period any system problems, errors, failures, or malfunctions that are not in compliance with the contract requirements shall be categorized based on the level of severity. The typical four levels of severity are:

- Severity 1 – Hardware or Software component or process critical to the operation of the EL that does not function, and there is the possibility of loss of revenue and/or loss of data.
- Severity 2 – Hardware or software component or process that does not function. There is no risk of loss of revenue or data; however, there is the possibility of negative impact to patron usage.
- Severity 3 – Hardware or software component or process that does not meet the design functionality and/or impedes the operation of the system but does not effect the collection of revenue or negatively impact the patron usage.
- Severity 4 – Hardware or software component or process that does not meet the design functionality and/or is “cosmetic” in nature. Failure is transparent in nature to both the patron and the ACCMA.

The success or failure of the 30-day OPT shall be determined by the number and type of severity levels encountered during the test. The following represents the impact of each of the severity levels on the eventual outcome of the test.

Severity 1

- Indicates a failure of the 30-day test.
- The 30-day test is stopped. Once the problem is resolved, the 30-day test is restarted from Day 1.
- Milestone payments regarding the 30-day test are withheld.
- Warranty period will not begin until successful conclusion of the OPT.

Severity 2

- Does not indicate a failure of the 30-day test.
- The 30-day test is stopped. Once the problem is resolved, the 30-day test will resume from the date it left off. Once the problem is resolved, the fix shall operate without flaw for seven consecutive days, which may extend the 30-day test period.
- Milestone payments regarding 30-day test will be withheld.
- Warranty period will not begin until successful conclusion of the OPT.
- Reoccurrence of the same problem might raise the level of the issue to Severity 1.

Severity 3

- Does not indicate a failure of the 30-day test.
- The 30-day test is stopped. Once the problem is resolved, the 30-day test will resume from the point it left off. Once the problem is resolved, the fix shall operate without failure for a minimum of seven consecutive days, which may extend the 30-day test period.
- Milestone payments will continue to be paid.
- The Warranty Period will not begin until successful conclusion of the OPT.

Severity 4

- Does not indicate a failure of the 30-day test.
- The 30-day test is not stopped. The problem is resolved in a timely fashion.
- Milestone payments will continue to be paid.

- The Warranty Period will not begin until successful conclusion of the OPT.

All EL hardware and software will be carefully tested. Verification that all reported problems have been resolved will be obtained using several methods, including event logs, service call logs, other information gleaned from the ETS Maintenance On-Line Management System (MOMS), which will be developed and maintained by the Integrator through the first year of operation, and any other data sources approved by the ACCMA. Multiple meetings per week will be scheduled during the 30-day test to ensure that the ACCMA is fully aware of all system and equipment failures. The meetings will provide a forum for the ACCMA and Integrator staff to review system/equipment failures and to classify the severity levels.

G. DEPLOYMENT PLAN GUIDELINES

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

DEPLOYMENT PLAN GUIDELINES

PLAN SECTIONS:

1. GENERAL
2. ROLES AND RESPONSIBILITIES
3. PURPOSE OF DEPLOYMENT PLAN
4. SYSTEM DEPLOYMENT PERSONNEL
5. INSTALLATION EQUIPMENT AND TOOLS
6. ELECTRONIC TOLL SYSTEM DOCUMENTATION
7. INSTALLATION CONSIDERATIONS
8. SYSTEM TESTING AND ACCEPTANCE
9. INSTALLATION SCHEDULE
10. INTEGRATOR TRAINING
11. CONCLUSION

1. GENERAL

The EL Deployment Plan will provide the details of the planned installation of the EL ETS roadside, TDC, TMC, and system enforcement equipment and subsystems. This document provides guidelines for the creation of the Deployment Plan by the Integrator.

2. ROLES AND RESPONSIBILITIES

To ensure successful EL deployment and operations, and to make certain that the delivered tolling system operates according to the RFP and Contract requirements, the EL project engineering organization will have various roles and responsibilities. Listed below are starting points for defining the various organizational responsibilities.

2.1 ACCMA PERSONNEL

The ACCMA ED shall have full contractual responsibility for all of the EL equipment and system deployment activities, and will work closely with the consultant and Integrator staff to ensure that equipment and system deployment is performed correctly.

2.2 PROJECT CONSULTANT STAFF

The ACCMA's EL tolling system consultant personnel will be responsible for ensuring that the Integrator creates and properly maintains equipment and system deployment engineering related processes, policies, and operating procedures. Consultant staff shall

participate in all facets of the deployment activities to verify that the deployment activities are conducted and administered correctly. The consultant shall provide any required technical assistance to the Integrator and ACCMA staff during the equipment and system deployment process.

2.3 INTEGRATOR ENGINEERING STAFF

The Integrator systems engineering personnel for the EL Project shall be responsible for developing all the documents required to support the EL equipment and system deployment process. Integrator staff shall perform all the work associated with deploying the ETS, including the required field testing, as described in the Verification (Test) Plan, the RFP, and the Contract documents.

The Integrator shall ensure that the equipment and system deployment requirements and processes are adhered to, including confirmation that the requirements within the trace matrix are met.

Integrator staff shall develop all the required system deployment documentation, which will be subject to the review and approval of the ACCMA. Integrator staff shall also perform any required testing and re-testing activities identified by the ED and the consultant staff. More details of the Integrator's staff are described in Section 4 below.

3. PURPOSE OF DEPLOYMENT PLAN

The Deployment Plan shall include, at a minimum, a comprehensive Installation Plan that includes a detailed schedule, a Training Plan, and an Installation Safety Plan.

The equipment and software deployment techniques that will be used on the EL Project by the Integrator shall be clearly defined in the Installation Plan and, if accepted by the ACCMA, will be applied to all the equipment, subsystem, and software installations. Specific step-by-step sequenced scenarios for the installation of roadside equipment, communications network, TDC equipment, enforcement equipment, and the TMC subsystem shall be provided by the Integrator, combined with the Installation Plan Schedule of these various activities. The objective of requesting that the Integrator present the information in this manner is to provide clear and concise details concerning specific installation requirements and techniques. The Installation Plan Schedule, which will be a sub-schedule of the Integrator Project Schedule, as described in the Development Plan Guidelines, shall match the relevant milestone dates that are presented in the Overall Project Schedule.

The following simplified sequence of deployment activities will be performed by the Integrator. The detailed Installation Plan Schedule, which will be provided by the Integrator, will show the individual tasks associated with the installation of equipment for each subsystem.

- Pre-Installation Activities as follows:
  - Verify civil and conduit work.
  - Work with the ACCMA to finalize the Installation Plan, Installation Schedule and other deployment documents.

  - Ensure that all safety procedures are in place.
  - Secure Caltrans Encroachment Permit.

- Roadside Equipment Installation as follows:
  - FasTrak Antennas and Readers.
  - Tolling Zone Lane Controllers.
  - Enforcement Beacons.
  - Vehicle Detection System (VDS) Equipment.
  - CCTV Equipment.
  - Communications Network Equipment.
  - Other equipment as identified in the RFP and civil plans.

- TDC Equipment Installation as follows:
  - Trip Processor Hardware and Software.
  - CSR workstations.
  - ACCMA EL Website.
  - Interface to the BATA RCSC.
  - Interface to the Caltrans TMC.
  - Interface to the CHP Enforcement Equipment.
  - Other equipment as identified in the RFP and civil plans.

- Post-Installation Activities as follows:
  - Verify that all the equipment and software is installed properly.
  - Verify that each internal subsystem communicates properly to each other.
  - Verify that all installed equipment and software operates properly by conducting end-to-end systems testing.

4. SYSTEM DEPLOYMENT PERSONNEL

4.1 ETS INTEGRATOR

The Integrator shall be fully responsible for all EL deployment activities and will provide leadership in the management of the equipment and system integration, installation, testing, and commissioning process. The Integrator shall provide the full, complete ETS, with full integration of the various other subsystem components that are expected to be procured from vendors, including the FasTrak equipment, VDS equipment, CCTV equipment, workstations, etc. It will be the responsibility of the Integrator to conduct the electrical work or to bring an Electrical Subcontractor on board to perform this work. The chosen Electrical Subcontractor shall be approved by the ACCMA prior to any work that is conducted in the field.

4.2 INTEGRATOR PERSONNEL QUALIFICATIONS

Only qualified Integrator personnel and their subcontractor representatives shall be present on site to perform any pre-installation or actual installation work. Integrator staff should have all required electrical licenses and other required installation permits prior to starting any work. Only highly skilled Integrator staff, with many years of toll system implementation experience, shall oversee the equipment and system deployment activities.

4.3 INTEGRATOR MANAGEMENT SUPPORT AND SERVICES

During the equipment and system deployment, and operational testing activities (as defined in the Verification Plan), the Integrator shall provide an integrated, well organized EL Management Team of staff from the Integrator and any of their subcontractors, including the FasTrak equipment vendor. All system deployment Team members shall be knowledgeable and experienced in their respective fields of expertise, and will provide a quality product within the schedule parameters that are established by the ACCMA. As part of the response to the RFP, the Integrator shall provide an organization chart clearly depicting the deployment Team along with documentation of their qualifications. The staffing shall be subject to the approval of the ACCMA.

4.4 INTEGRATOR PROJECT MANAGER

The Integrator shall nominate a Project Manager (PM) who will be subject to the approval of the ACCMA. The Integrator's PM shall be the ACCMA's single point of contact throughout the entire Project. During the deployment effort, the Integrator PM's primary responsibilities shall include, at a minimum:

- Primary communications with the ACCMA and their consultants;
- ETS Contract administration;
- Ensure that the Integrator adheres to the quality assurance and control process;
- Schedule and administer the ETS Project status meetings;
- Interface with the Integrator's Installation Manager and all of the Integrator's subcontractors; and
- Coordinate with California regulatory agencies, Caltrans staff, BATA personnel, permitting agencies, vendors, etc.

The Integrator PM shall ensure that all resources are allocated to the EL Project and are used in the most advantageous manner. Additional Integrator Deployment Team members are listed below with their areas of expertise and their specific responsibilities.

4.5 CHIEF TECHNICAL OFFICER

The Integrator Chief Technology Officer (CTO) shall be responsible for all technical functions on the EL Project. During the equipment and system deployment and installation activities, the CTO's responsibilities, at a minimum, shall include:

- Equipment specifications (hardware and software);
- Contractual documentation;
- Testing and acceptance procedures;

- Integration testing and debugging; and
- 90-Day System Performance Testing.

4.6 INSTALLATION MANAGER

The Integrator's Installation Manager shall be responsible for the proper installation of all on site equipment as well as local installation support requirements and purchases. The Installation Manager will remain on site during the entire equipment and system installation phase of the EL Project, including the post-commissioning testing phase. The Installation Manager will be responsible to confirm that all of the subcontractor work is completed properly and meets the System Requirements as approved by the ACCMA. The Installation Manager shall recommend acceptance of the equipment and system by the ACCMA.

The Installation Manager's responsibilities would include, at a minimum:

- Site survey;
- Verify civil work;
- Supervise cable and fiber optic installation, splicing and testing;
- Supervise equipment installation and start-up;
- Warehouse and inventory control;
- Maintain field records and installation logging; and
- Develop and maintain safety records.

4.7 HARDWARE INSTALLATION ENGINEER

The Integrator's Hardware Installation Engineer shall be responsible for the hands-on installation of all roadside equipment and all hardware installed at the TDC, on the CHP vehicles, and at the Caltrans TMC. The Hardware Installation Engineer shall be on-site as necessary during the installation phase of the EL Project and shall have, at a minimum, the following responsibilities:

- Supervision of other Integrator hardware installation personnel;
- Installation of the roadside equipment;
- Supervision of any subcontractors that might provide FasTrak, CCTV, VDS and enforcement equipment;
- Supervision of the Electrical Subcontractor, if the Integrator chooses to use the services of a subcontractor, on roadside equipment power wiring terminations;
- Terminations of roadside, enforcement and TDC equipment control wiring; and
- Lane equipment start-up and verification testing.

4.8 TDC INSTALLATION ENGINEER (HARDWARE AND SOFTWARE)

The Integrator's TDC Installation Engineer shall be responsible for the required hands-on installation of TDC hardware and software, including the interfaces to the Caltrans TMC, the BATA RCSC, and the CHP vehicles in support of the enforcement process. The TDC Installation Engineer shall be on-site after the communications network has been

successfully installed and tested. The TDC Installation Engineer shall have, at a minimum, the following responsibilities:

- Supervise other TDC related Integrator hardware and software personnel;
- Install all required switches and hubs to the TDC patch panels;
- Test the TDC local area network (LAN) to ensure its proper operation;
- Install all the TDC servers and software;
- Configure TDC servers operating system;
- Configure and install the various TDC workstations and peripheral hardware;
- Install the application software on the TDC servers and workstations; and
- Test roadside, BATA, Caltrans and CHP enforcement equipment connectivity and data transfer process.

4.9 ROADSIDE EQUIPMENT SOFTWARE SUPPORT ENGINEER

The Integrator shall also appoint a Roadside Equipment Software Support Engineer to the EL Project who will be responsible for overseeing the Integrator's roadside equipment and subsystem testing activities. The Engineer shall be on-site as necessary subsequent to the successful installation and pre-testing of the roadside equipment by the Integrator's Hardware Installation Engineer. The Roadside Equipment Software Support Engineer shall have, at a minimum, the following responsibilities:

- Oversee the fine tuning of the FasTrak equipment once the antennas have been successfully tuned by the vendor;
- Oversee the Integrator testing activities of the roadside ETS equipment to include both the low speed and high speed testing (of up to 100 mph); and
- Ensure that the FasTrak lanes provide the correct data and other system information to the lane controllers and on to the TDC, in close cooperation with the TDC Installation Engineer.

4.10 SUBCONTRACTORS

All EL work proposed to be performed by a subcontractor(s) shall be clearly defined in the Integrator's Technical Proposal, and in the equipment and system deployment and installation documentation that they shall be required to develop. The ACCMA shall have the right to accept or reject any subcontractor.

5. INSTALLATION EQUIPMENT AND TOOLS

During the equipment and system installation process, the Integrator installation crews will have at their disposal all the necessary drills, cutters, and hardware tools to support the installation effort. The Integrator shall provide a detailed list of all required equipment and tools needed to support the deployment effort. Below is a typical list of the different types of equipment and tools required to properly install a tolling system:

- All required safety equipment necessary for a safe system installation, including (but not limited to) steel-toe boots, safety cones, hard hats, eye protection, fall protection to 6 feet, safety vests, first aid kits, etc;
- All necessary layout, electrical and mechanical drawings;
- Platform truck for canopy installation and a palette jack and/or truck lift gate to unload heavy equipment;
- Fiber optic polishing and termination tool kit, mesh slings to grasp cable ends that must be pulled from conduits, conduit mandrill to clean out blocked conduits, cable markers, a bonding product to secure loop and wires in a VDS loop cut, inductive loop cutting machine, loop sealant; and
- An assortment of tools, including hammers, measuring tapes, hacksaws, pliers, screwdrivers, step ladders in varying sizes, tools for terminating various types of cables, etc.

During the initial 90-Day Operational Test, a complete software development system shall be made available by the Integrator for quick on-site debugging capabilities.

6. ELECTRONIC TOLL SYSTEM DOCUMENTATION

A complete and updated set of ETS related documentation shall be kept by the Integrator at their EL Project office, which should be located near the three tolling zone locations and the TDC site. Integrator technicians shall retain their own set of documentation in accordance with their specific needs, in a secure manner, which will periodically be checked by the appropriate Integrator manager to ensure its revision validity. All documentation shall be conveyed to the ACCMA both in hard copy and electronically. The ACCMA shall retain an updated version documentation file for Project consistency.

7. INSTALLATION CONSIDERATIONS

7.1 INSTALLATION SAFETY

During the equipment and system deployment process, at all times, job safety shall be of paramount importance for everyone who might have access to the roadside and TDC equipment. All Integrator personnel, before being allowed to provide direct installation support, shall comply with all safety and drug screening requirements established by the ACCMA. Integrator staff working on the installation phase of the EL Project shall also participate in a ACCMA approved safety orientation session, which will include information about Caltrans encroachment permit requirements. The Integrator installation staff is also required by the ACCMA to use the following personnel safety equipment:

- Hard hats;
- Eye protection;
- Steel-toe boots;
- Reflective safety vests, and
- Fall Protection (up to 6 feet).

All Integrator and subcontractor installation personnel shall be provided with the ACCMA safety requirements to ensure that they are familiar with the various on-site job safety requirements. The Integrator shall also provide weekly safety briefings that involve all Integrator and subcontract personnel to confirm that they are adhering to the ACCMA safety requirements. The Integrator shall be required to develop, submit for ACCMA approval, and periodically update a General Safety Plan. This Plan shall be adhered to in order to ensure the safety and well being of all involved installation personnel, as well as motorists and pedestrians near or approaching the work site.

7.2 CODE AND INDUSTRY STANDARDS

All applicable codes and standards shall be adhered to by the Integrator. The ACCMA will periodically check to confirm that all required standards are being met by the Integrator.

7.3 INSTALLATION PLANNING

As described previously in this document, a detailed Installation Schedule shall be developed by the Integrator, submitted to the ACCMA for approval and periodically updated. Any changes are subject to approval by the ACCMA. This Schedule shall be updated on a weekly basis with the progress of detailed tasks in a percentage completion format. This Schedule will be formatted to provide a separate schedule with at least a two-week look ahead feature that will be used during the Integrator/ACCMA weekly progress and planning meetings. The Integrator will be expected to closely coordinate all work with other EL Contractors as required to ensure that simultaneous work efforts can be accomplished as quickly as possible.

7.4 WEATHER AND PRODUCTIVITY

The Integrator should make every effort to plan for weather delays and productivity concerns during bad weather conditions. For example, some of the work at the TDC could be saved as a fall back for when bad weather appears. The emphasis during good weather should be focused on outside work, including gantry or canopy equipment and conduit installation.

7.5 SHOP DRAWING SUBMITTALS

The Integrator shall be required to develop and submit shop drawings prior to the installation, to enable sufficient time for the ACCMA review and approval process. The drawings shall be updated and revised to reflect the actual installation conditions. The updated shop drawings would be resubmitted by the Integrator as final As Built drawings.

7.6 INSTALLATION DAILY CLEANUP

The Integrator and their Subcontractors shall thoroughly clean up their work area on a daily basis and leave the installation site in an orderly manner.

7.7 INSTALLATION RECORDS

A detailed installation log of the Integrator’s work effort at each location shall be developed, maintained carefully, and submitted as part of the weekly review meetings with the ACCMA.

8. SYSTEM TESTING AND ACCEPTANCE

Once the EL system has been subjected to complete Integrator and ACCMA verification testing and commissioned as defined in the approved Verification Plan, the Operational 90-Day Test period shall commence to ensure that the system is operating at a level that warrants acceptance by the ACCMA. During the Operational 90-Day Test period, the Integrator shall provide full system support and maintenance. Refer to the Verification (test) Plan for additional details.

During this testing period, Integrator personnel shall be available on-site to perform all their required duties. Integrator staff shall perform all preventive, corrective, and emergency maintenance, as necessary, to ensure the proper performance and operation of the EL system. As equipment, subsystem, and overall system reliability is the primary testing concern during this period, the Integrator shall strictly adhere to all ACCMA mandated maintenance and testing procedures. Closely observing this common sense approach will permit the Integrator to achieve successful levels of performance, reliability, maintainability, and therefore system availability and performance. The goal during this Test is for the Integrator to provide the ACCMA with sufficient evidence that the installed EL system meets all the reliability and operating requirements presented in the RFP and the other Contract documents. Concurrently during the test, the various maintainability requirements shall be demonstrated by the Integrator.

8.1 OPERATIONAL 90-DAY TEST RECORDS

Integrator staff will keep various operational and maintenance records during the test period. All identified problems, failures, malfunctions, service calls, and any inappropriate performance of the equipment, software, subsystems, or overall system shall be clearly documented and submitted for review by the ACCMA on at least a weekly basis.

8.2 CORRECTIVE ACTION

Any problems that surface during the 90-Day Test that might reveal that a piece of equipment does not meet the operational, reliability, maintainability or accuracy requirements, will be analyzed and resolved by implementing an appropriate revision. The ACCMA shall be kept completely informed of the situation and, when it is resolved, the ACCMA will be provided with the details of the revision and/or solution that was implemented.

8.3 OBSERVATION AND 90-DAY TEST RECORDS

A copy of accurate service reports shall be submitted by the Integrator to the ACCMA on at least a monthly basis. ACCMA staff will have access to all service records at all times. A hardware and software Maintenance Log shall be kept continuously by Integrator personnel. All preventive, corrective, emergency maintenance, software changes, and/or upgrades performed on any equipment during the Test period will be carefully noted in the Maintenance Log.

The Log will require a description of the fault and the effort to repair it, the serial numbers and the name of the equipment that was worked on, the date and time of the start and finish, the technician's name(s), the problem notification time, tolling zone location, and signature boxes for both the ACCMA and Integrator staff to sign. This data will provide

valuable records of the equipment and system operations which will help the ACCMA and the Integrator in establishing, after analysis, more accurate preventive maintenance schedules, spare parts levels, maintenance personnel requirements, and a clear indication of reoccurring problems to particular pieces of equipment. This data will become especially important as the Integrator closely tracks equipment, subsystem and system operation during the 12-month Warranty Period.

9. INSTALLATION SCHEDULE

As described previously in this document, the Integrator shall develop and submit, for ACCMA review and approval, a detailed EL Installation Schedule. The Schedule shall include a clear and concise description of what piece of equipment, subsystem, etc., that the Integrator proposes to install at what location. It will also state the expected time it will take for each piece of equipment, subsystem, etc. to be installed, tested and deployed. Integrator and ACCMA personnel shall follow the various dates presented in the Installation Schedule to ensure the EL system deployment process stays on schedule.

10. INTEGRATOR TRAINING

The training of ACCMA personnel shall be provided shortly before they initiate hands-on operation of the EL system, in order to retain as much of the training knowledge as possible. The training process overview will be as follows:

- TDC Supervisor staff:
    1. TDC system operator overview
    2. TDC workstation overview
    3. Interface to the BATA FasTrak account management system
    4. Interface to the Caltrans TMC
    5. Interface to the CHP enforcement system
    6. Navigation of the ACCMA website
    7. Access to the Maintenance On-Line Management System (MOMS)
    8. Access to Integrator maintenance staff
    9. Access to EL Operations staff (if the ACCMA chooses to use the Integrator or a second source company)

- TDC Customer Service Representative staff:
    1. TDC system CSR overview
    2. TDC workstation overview
    3. Interface to the BATA FasTrak account management system
    4. Interface to BATA CSRs
    5. Navigation of the ACCMA Website

11. CONCLUSION

The Integrator will develop System Deployment Plan Guidelines that clearly describe the management approach that will be implemented to ensure that the EL ETS deployment activities are performed correctly. The Integrator's Deployment Plan shall include all required information regarding their approach to managing the

equipment, software and system installation and deployment process, their planned testing procedures that will be used, etc.

H. ELECTRONIC TOLL SYSTEM REQUIREMENTS

I-580 EB EXPRESS LANES PROJECT
SYSTEM ENGINEERING MANAGEMENT PLAN

ELECTRONIC TOLL SYSTEM REQUIREMENTS

PLAN SECTIONS:

1. PURPOSE OF THIS DOCUMENT

The purpose of this document is to describe the functional and performance I-580 Eastbound EL electronic toll system (ETS) requirements, various operating business rules, and interfaces to external systems. This document will be reviewed and approved by Alameda County Congestion Management Agency (ACCMA) and will be used as the basis for developing the ETS Request for Proposals (RFP) document to procure the ETS. As a consequence, the requirements presented herein will affectively be used as the basis for the validation of the designed, developed and delivered ETS as described in the *Verification (Test) Plan* (Appendix F). Any future changes and/or additions made to these requirements must also be approved by ACCMA staff prior to their inclusion in this document.

2. DEFINITIONS, ACRONYMS AND ABBREVIATIONS

The various definitions, acronyms and abbreviations that are used throughout this section are identified in a matrix that is presented previously in this document.

3. GENERAL OVERVIEW

3.1. GOALS OF THE EL SYSTEM

In order to provide better traffic flow on I-580 in Alameda County the proposed eastbound High Occupancy Vehicle (HOV) lane will be converted to the High Occupancy Toll (HOT) lanes referred to as Express Lanes (EL) for this project. The Project Limits are from just west of the Hacienda Drive Interchange near Dublin to just east of the Greenville Road Undercrossing. The California Legislature under AB 2032 and the Federal Highway Administration (FHWA) authorized this project to improve travel efficiency in the corridor and provide more options to individual travelers. AB 2032 originally included a sunset provision that authorized the operation of the pilot program for a period not to exceed four years after the agency first collects revenues and specifies that HOV users will travel free and excess capacity may be sold to low occupancy vehicles. California State Assembly Bill 574 (AB 574) approved on October 11, 2007, eliminated the sunset provision on the EL that AB 2032 required. The ACCMA has been tasked and authorized to convert the existing HOV lane in the eastbound direction into an EL. The ACCMA will administer and operate the Eastbound I-580 EL. The California Department of Transportation (Caltrans) is responsible for design review and construction oversight of the eastbound I-580 standard EL, which will be constructed in two (2) phases. Through conversion of the HOV lane to a EL, the project will achieve the following goals:

1. Better utilize the HOV lane to improve traffic throughput in the corridor; and
2. Optimize this new revenue stream to help pay for transportation improvements and transit operations in the corridor.
3. Provide a free flow alternative during periods of congestion to HOV users without charge and to SOV users for a varying demand elastic toll.

3.2. METHOD OF TOLL COLLECTION

The toll collection system to be deployed on the EL will be fully electronic and initially utilize Radio Frequency ID-based (RFID) Automatic Vehicle Identification (AVI) technology as the only method of payment (upgrade to Dedicated Short Range Communications (DSRC) is expected when offered by a Title 21 vendor). The tolling system shall be designed and developed to operate within the Title-21 requirements. This method of toll collection is known as Electronic Toll Collection (ETC). The ETC system to be deployed on the EL will be FasTrak™, which is the current standard in California. Single occupancy vehicle (SOV) operators will be required to obtain a FasTrak™ transponder, also commonly referred to as a tag, from the Bay Area Toll Authority's (BATA) regional customer service center (RCSC), designated retail outlets, and other California toll agencies.

In contrast to the current HOV system in use in Northern California that allows eligible HOVs to enter and exit at any point along the facility, the EL configuration will restrict access and only allow entry and exit at strategic access points. The ETS will carefully track and record when a FasTrak™ transponder passes through a toll zone in order to

ensure that the appropriate price charged is never more than what was displayed to the SOV user just prior to entering the facility.

3.3 HOURS OF OPERATION

The EL shall operate 24 hours a day, 7 days a week, pending approval of the hours of operation of the HOV lane.

3.4. DIVISION OF EL RESPONSIBILITIES

3.4.1. ALAMEDA COUNTY CONGESTION MANAGEMENT AGENCY (ACCMA)

The ACCMA, as the owner of the EL facility, will be responsible for the following:

1. Operation, monitoring, maintenance and technical support of the entire lane-level ETS, including: the FasTrak™ readers and antennas, the dynamic message sign (DMS) modules, EL advisory fixed static signs, tolling zone controllers, vehicle detection station (VDS) equipment (both intrusive and non-intrusive), closed circuit television (CCTV) equipment, EL equipment/tools supporting California Highway Patrol (CHP) enforcement, communication gear supporting EL operations (including link to a toll data center (TDC);

2. EL dynamic pricing calculation, traffic data processing, toll transaction processing, trip generation process, and audit and reconciliation process, which shall be done at the TDC;

3. Back-office (i.e., TDC) equipment, hardware and software supporting lane equipment monitoring and control, administration, data processing, data storage, reporting and maintenance; communication gear supporting a local area network (LAN) and links with the DMS, RCSC, Caltrans TMC and the CHP enforcement equipment/tools;

4. Customer Service Center (CSR) functions supporting representatives dedicated to assisting I-580 EB EL users in account enrollment and management, along with resolving complaints and account related problems audit performed remote of the RCSC;

5. Capability to remotely monitor EL operations and performance from an agency location if the ACCMA chooses to out-source EL operations to a contractor/service provider;

6. Perform lane and/or shoulder closures, with Caltrans's approval, to properly maintain and support the EL equipment and software;

7. Maintenance of the EL static signs and highway lighting installed at the ingress and egress points;

8. EL marketing strategy, plans and promotions; and

9. EL performance evaluation and user type (i.e., HOV, SOV, violator) audit within 3 years of system opening.

3.4.2. BAY AREA TOLL AUTHORITY

BATA will be responsible for the following:

1. Full Regional Customer Service Center (RCSC) processing, including FasTrak™ account management, customer service interface for enrollment and account activities, EL trip record processing, revenue and data exchange/reciprocity with other California Toll Operators Commission (CTOC) agencies, payment processing, and fee revenue management;

2. Modifications to RCSC software to accommodate EL FasTrak™ account statements and reporting requirements;

3. Managing existing FasTrak™ transponder inventory management system (including automatic tracking and reorder process), and transponder fulfillment for EL users;

    4. Web site servicing, security protection and maintenance, including link to Agency Web site;

    5. Support I-580 EB EL CSRs with call center traffic overflow and servicing;

6. Operate, support and maintain FasTrak™ back office operations; and

7. Build and periodically transmit tag status file and updates to TDC, generate and transmit FasTrak™ transaction and revenue and ad hoc reports to the ACCMA.

3.4.3. CALIFORNIA DEPARTMENT OF TRANSPORTATION

Caltrans will be responsible for the following:

1. Safe operation of eastbound I-580;

2. Incident response management for the Eastbound I-580 EL;

3. Override of the EL DMS module messages, in coordination with ACCMA staff, if a situation arises that warrants an override of the ETS operation, as defined in the ACCMA/Caltrans Agreement;

4. Operation of a Traffic Management Center (TMC) designated to receive traffic data and roadway surveillance video from the TDC and invoke override functions to change DMS module display for the I-580 EB EL ; and

5. Roadway maintenance of the entire facility other than the ETS and FasTrak™ equipment.

4. EL ELECTRONIC TOLL SYSTEM

4.1. TOLL DATA CENTER SYSTEM

1. The TDC shall function as the primary data processing, storage and reporting central processing unit for the EL system.
2. The TDC shall interface with the following ETS components that comprise the EL system:
    - 2A - Toll zone lane controllers;
    - 2B - Dynamic toll rate display module controllers installed as part of each DMS;
    - 2C - System enforcement equipment/tools used by the CHP;
    - 2D - The Caltrans TMC;
    - 2E - The BATA RCSC;

4.1.1. Primary Functions of the TDC

4.1.1.1. Traffic Pricing Calculation

1. 1. Dynamic pricing calculation and toll rate setting process shall be formulated by the Integrator during the ETS design phase of the project using the dynamic pricing parameters incorporated into the ETS RFP as a guideline.
2. The TDC shall periodically and dynamically calculate the toll rate based upon traffic information the EL VDSs and MF Remote Traffic Microwave Sensor (RTMS) devices installed along facility.
3. The toll rate setting process shall accommodate the objective to maximize gross toll revenue, subject to:
    - 3A - a maximum toll,
    - 3B - a minimum Level of Service C as defined in the Highway Capacity Manual,
    - 3C - a dynamic re-pricing interval of no less than 5 minutes,
    - 3D - a carpool toll exemption set by policymakers, and
    - 3E - reservation of excess downstream EL capacity based on historical HOV demand level and as set by policymakers.

4. The Integrator shall maintain sufficient design flexibility so as to permit incorporation of objectives such as maintenance of minimum LOS or other objectives in the future.

5. The toll rate setting process shall assess a toll rate for travel to an interchange in each of 1-3 segments that reflects the current trend of HOV and SOV demand and the measured traffic parameters that relate traffic density to a particular price that is validated by the current measured trend in the MF lanes.

6. The Integrator shall provide, at a minimum, the following:
    - 6A - A dynamic, real-time, parameter-driven toll rate setting process that successfully meters EL SOV traffic demand and ensures that the EL LOS threshold and other operational constraints are maintained. The toll rate setting process may consist of mathematical functions, algorithms, statistical procedures, and hardware and software implementations of such;
    - 6B - A toll rate setting process that accounts for traffic densities in the EL and vehicle travel times in the MF lanes;
    - 6C - A toll rate setting process that accounts for disparities in traffic densities occurring simultaneously throughout the entire length of the EL corridor;
    - 6D - An interval of change for the toll rate (i.e. not less than every 5 minutes) that successfully meters EL demand without creating driver confusion by changing too frequently;
    - 6E - An individual user selectable toll rate increment of $d.cc (where d- stands for dollars, and cc stands for cents) that successfully smoothes price movements to mitigate erratic changes in EL demand;
    - 6F - A user selectable minimum toll rate of $1.00;
    - 6G - A user selectable maximum toll rate; and
    - 6H - A dynamic pricing structure that provides the ability to toll by segment.

7. The toll rate setting process shall also provide the following:
    - 7A - A fall-back toll-setting method to accommodate abnormal operating conditions or equipment failures,
    - 7B - Methods for automatic, manual or semi-manual refinement of the process and sub-processes (see 5. below),

- 7C - Methods for seeding and training of any dynamic toll optimization routines employed that measures System response to known stimuli (i.e., trip price) over a stable traffic time period, and

8. The period at which the TDC calculates the toll rate shall be a user-selectable, table-driven parameter in the ETS. The specific calculation interval shall be initially set during the ETS design phase of the project, but the system shall provide the ability for the ACCMA Executive Director (ED), or his designee, to modify the parameter at any time in the future. The setting of the calculation shall be possible by non-technical persons, and designed so as to alert the technicians to a parameter that is out of a defined range.
9. The toll rate setting process will be able to make use of at least the following real-time and archived historical performance information:
    - 9A - vehicle volumes and speeds in the MF lanes up-stream of pricing sign location and at each pricing location,
    - 9B - carpool vehicle volumes based on audited violation rate for the particular time period being analyzed,
    - 9C - expected trip revenue used to reconcile RCSC revenue reports for user selectable revenue days (base on on-line and or archived data),
    - 9D – any other processing deemed necessary by the Integrator to achieve the toll-optimization and management objectives set forth herein.
10. The traffic data shall be collected from the EL via electromagnetic loops that will be installed at maximum intervals of one (1) mile.
11. The standard Caltrans double loop configuration shall be used in the EL.
12. To capture traffic data in the MF lanes, RTMS devices shall be installed outside the right shoulder approximately every mile along the I-580 EB EL corridor. RTMS equipment shall be used to collect raw traffic data from the MF lanes and also used to back-up the collected EL traffic data (i.e., volume, occupancy and speed).
13. The TDC shall collect traffic data at a minimum interval of every 15 seconds. However, the implemented time interval for traffic data collection by the TDC shall be determined by the ETS Integrator (Integrator) during the system design phase of the ETS Project and approved by the Agency.

4.1.1.2. EL Trip Assembly

1. The TDC shall be responsible for gathering and compiling traffic, transaction, and alarm/event data from all tolling zone controllers and building individual trip transaction records sent to BATA RCSC for processing. The TDC shall also be responsible for compiling calculated toll rate data for building trip rate tables used

to assign tolls to trip records and processing tag status file and updates received from the RCSC that is sent to the zone controllers to build SOV transactions.

When a FasTrak™ transponder enters the EL facility and passes through a tolling zone, a handshake between a vehicle mounted transponder and an overhead antenna/reader initiates the transfer of data used by the zone controller to validate the transponder by comparing the transponder ID number to the current tag status file that is resident in the lane controller's memory. Data, including the transponder ID number, date, time, a tolling zone location code, and a status code for any defective lane equipment shall be sent to the TDC in a transaction record. This series of events occurs every time a vehicle that is equipped with a FasTrak™ transponder passes through a EL tolling zone. Therefore, each time a vehicle traverses a tolling zone a distinct transaction record shall be built, stored and forwarded to the TDC. The zone controller shall be capable of storing up to 30 days of transaction records in a circular file format.

2. If a transponder is detected but it is determined to be valid, the zone controller shall send a command to illuminate the tolling zone beacon. The beacon shall illuminate within 0.1 seconds from the time in which the zone controller makes this determination. For vehicles without a transponder or having an invalid transponder read a transaction record shall be built by the zone controller without a transponder ID number and sent to the TDC. Vehicle user type could be either a valid HOV or violator that requires on-site enforcement to make the distinction.

3. The TDC computer shall then compile each of the vehicle transaction records and alarm/event data collected and determine where the trip began, segments traveled, and the trip end by scanning and separating stored records having the same transponder ID and occurring within 30 minutes (configurable) before or after each other.

4. The TDC shall then use the time and date of the first transaction record of a particular transponder ID trip to assign a toll to the trip record using a pricing table that relates location code and time intervals to DMS displayed tolls. Rule based processing will be used to derive a pricing table lookup time that accounts for the travel time from just upstream of the DMS to the toll zone. While travel time on the EL facility is deterministic using the current measured speed, travel time on the mixed flow lane before entering the facility is more difficult to accurately determine. Consequently, using the lower of the price corresponding to subtracting only the EL travel time from the toll zone transaction time and the displayed price in the time interval preceding this calculated time assures a fair price to the user.

5. Based upon the above internal calculations, the TDC shall then develop a EL trip record, store this record in the proper location and send the trip record to the BATA RCSC for posting to the FasTrak™ customer account. These results in the realization of revenue by the ACCMA associated with a particular trip record. The

TDC shall be designed to store EL trip records for the length of time required by law.

6. The ETS shall include parameters that define the maximum duration for a single trip as well as a maximum time between trip transactions and logic that adjusts for a loss of communications with one or more tolling zone controllers encountered along a trip (except for the first or last trip toll zone).

7. The EL system shall be configured to charge one price per trip, for example the price that is displayed on the DMS module as the vehicle enters the EL for travel to a particular displayed destination (or one within the same Segment of the displayed destination). This presumes that the pricing signs are capable of displaying a maximum of three destinations and associated prices corresponding to a maximum of three Segments within which prices to any destination is the same from a particular origin.

4.1.1.2.1 Pricing Safeguards

1. When a vehicle enters the EL, the displayed price might change between the time at which the driver views the toll rate on the DMS module and the time at which the driver passes through a tolling zone. Based upon near real-time speed data, the TDC shall calculate the amount of time it takes for a vehicle to travel from ingress to tolling zone that is located immediately downstream from the pricing sign. The process described above will be used to assure a SOV user is never charged more than the price that was displayed when the user was approximately 100 feet in front of the pricing sign.

2. The TDC shall also include the capability to periodically send a time of day (TOD) pricing table based on average historical prices (for peak, off-peak and shoulder time periods) to the DMS module controller for use during loss of communications. The DMS module controller shall be configurable to operate in standalone mode using a TOD, fixed, or blank-out pricing scheme

4.1.1.3. EL Trip Reconciliation

1. The TDC shall include EL trip audit and reconciliation functionality. It shall provide a secure user interface that allows TDC personnel to view and reconcile EL trips sent to the RCSC and revenue recognized for user selectable time periods. Authorized TDC operators will have access to the RCSC database through a secure user interface to generate reports and retrieve selectable account data to reconcile trips with revenue and respond to management and customer inquiries. The interface shall also include ad hoc reporting capabilities that allow users to create, execute, and store reports.
2. This interface shall provide detailed transaction data such as tag-read times and locations, pricing data, compiled traffic data, and other supporting raw transaction information for selectable time periods and specific transponder ID numbers. This

information shall then be used to verify that trips were properly built and respond to reconciliation issues and customer inquires.

3. This interface shall allow authorized users to make adjustments to the data and correct errors in SOV trip records due problems related to the following: zone controller time synchronization, displayed TOD pricing during communication loss, cross lane (i.e., MF) transponder read, precise start and end of TMC override during which no toll is assessed, failure to timely close facility due to lane blockage, and other events necessitating an adjustment in accordance with the business rules. . Users shall be able to adjust individual trip records or group/batches of trip records for a user selectable time period for various reasons as described above.
4. The TDC database shall store configurable audit parameters, and provide a permanent audit log to trail any adjustment made to summary or detail information.

4.1.1.4. Tolling Zone Operation Monitoring

1. The TDC shall include a secure, browser-based user interface that shall allow authorized users to view raw, detailed and summarized transaction and alarm/event data, as it occurs in real-time, at each tolling zone.
2. The tolling zone controllers shall broadcast data in near real-time to the TDC and this data shall be formatted and displayed in an easily understood, graphical manner. Real time monitoring shall support a screen displaying consolidated data for all tolling zone and the ability to drill down to a screen showing data sent from a selected tolling zone. Real time monitoring shall also support a screen showing summarized traffic data in a graphical format for the EL facility and the adjacent MF lanes. The capability shall be provided to view traffic data in real time or for a user selectable time period for a Segment and tolling zone.
3. Presented below is typical example data:

    - 3A – Detailed information on the last 10 SOV transactions;
    - 3B – SOV transactions and/or segment traffic volume, occupancy and speed during the last 15 minutes, last 30 minutes, last hour, since 6:00 a.m., etc;
    - 3C - Discrete messages and alarms/events from a tolling zone, including
    - 3Ca - Transponder Identification (ID);
    - 3Cb - Transponder read time;
    - 3Cc - Transponder handshakes (the number of times during vehicle passage through a tolling zone that the transponder and antenna attempt to establish communication with one another);
    - 3Cd - Vehicle speed on a particular segment;
    - 3Ce - Traffic volume on a particular segment;
    - 3Cf - Travel time data in the MF lanes;
    - 3Cg Toll zone controller alarms/events;
    - 3Ch –Traffic controller (for loops & RTMS) alarms/events;
    - 3Ci - DMS module controller alarms/events.

4. The real time monitoring user interface shall support ACCMA defined classes and sub-classes of users based on assigned roles for authorized access privileges to screens, menus, database tables, zone controller data, system logs, and specific functionality. User ID and password authentication shall restrict a user based on their class assigned by an authorized system administrator. High level user classes shall include customer service, facility operations management, and maintenance.

5. The interface shall protect customer information and operate under the requirements of California State privacy legislation.

4.1.1.5. TDC Reporting

1. TDC shall provide a fully integrated reporting module to support the needs of ACCMA management, accounting (audit and reconciliation), operations, and maintenance.
2. The reporting module shall generate scheduled traffic, trip and transaction reports from data stored at the TDC as well as support for ad hoc reporting needs.
3. TDC shall download account revenue data from the RCSC for use by the reporting module to generate scheduled revenue, reconciliation, and audit reports.
4. The reporting system shall allow users to browse, choose, and run reports through a clearly displayed and user-friendly Graphical User Interface (GUI) based on user selectable parameters.
5. The reporting system user interface shall support interconnection to the RCSC reporting system to allow authorized users to remotely generate and download reports for printing and displaying on-line at the TDC.
6. The reporting user interface shall allow reports to be generated, saved, displayed or printed in at least the following formats:
    - 5A - On-screen;
    - 5B - PDF;
    - 5C - HTML; and
    - 5D - Excel.
7. When accessing or running reports, the execute-to-display or execute-to-print time shall be less than one minute for each request.
8. The TDC report server shall be operational and available 24 hours per day, seven days a week.
9. Presented below is a list, at a minimum, of the required sample TDC reports:

    - 8A - EL Revenue Report;
    - 8B - EL Traffic Report (by segment and entire facility);
    - 8C - EL Trip Posting (to BATA) Report;
    - 8D - EL Lane Trip Reconciliation Report;

- 8E - Transaction and Trip Adjustment Report;
- 8F - Tolling Zone History Report;
- 8G - Detailed SOV Trip and Transaction Report;
- 8H - Traffic and Revenue Audit Report;
- 8I - Pricing Table by Segment and Time Interval;
- 8J - EL Travel Time Report (be segment and by facility);
- 8K - MF Lane Travel Time Report (by segment and by facility);
- 8L - Equipment Status and Maintenance Reports;
- 8M - Spare Parts Inventory Report;
- 8N - Asset Management Report;

4.1.1.6. Data Transmission

1. Data transmissions originating from the TDC shall occur automatically and utilize guaranteed delivery protocol.
2. Data communication between the TDC and the EL Lane Web site shall be via an Ethernet connection and protected by a firewall.
3. Data communication between the TDC and the BATA RCSC shall be via FTP for sending EL trip records and receiving account revenue data via pre-configured directory.

4.1.1.7. TDC Security

1. The TDC shall securely maintain EL data that is accessible through a standard login process requiring user ID and password.
2. Secure user accounts shall be administered through a system administration interface.
3. The system shall operate under the provisions of all California State privacy laws. For example, customer shall be masked to maintain customer privacy when viewed by all operations personnel except for authorized supervisors.
4. The database shall use security service enterprise authentication for connections to the database. This will centralize database security in one location.
5. All users shall have a user name and password that is the same across all databases.
6. Users shall have individual resource usage limits set for them to prevent unauthorized or excessive utilization of system resources.
7. Profiles shall be used to define resource usage limits by work activity or assigned user class.
8. Users shall be granted profiles according to their job needs.
9. The database shall be able to restrict data access down to the row level.

4.1.1.8. Receipt and Downloading of Tag Status Files

1. The TDC shall receive, at least once per day, an updated tag status file from the BATA RCSC.

2. The file acquisition process shall adhere to the BATA Interface Control Document (ICD), a copy of which shall be presented in the appendices of the ETS RFP.

3. The TDC shall automatically, upon receipt of tag status data from the RCSC and integrating the files into the TDC database, download either the full or an incremental tag file updates relative to the currently stored file to each of the tolling zone controllers. The incremental tag status file download would include any new FasTrak™ accounts or changes to existing accounts.
4. The method of file download shall be according to the BATA RCSC ICD.

4.1.1.9. Mobile Enforcement Equipment Data Transmission

1. The TDC shall send tag status data to portable and on-board mobile enforcement equipment terminals using wireless communications to enable the CHP officers to enforce the EL.
2. A secure wireless communications network shall be used to assure on-board and portable enforcement equipment/tools obtain the tag status file data in a real-time basis.

4.1.2. SYSTEM TO SYSTEM INTERFACES

1. The TDC shall be required to interface with three other systems to obtain data required for EL operations.
2. The BATA RCSC shall be the single point in which EL toll trips shall be transferred for posting, which shall include debiting the trip charge from the FasTrak™ customer account balance. The TDC shall also receive tag status files from the RCSC and account revenue data on at least a daily basis and CRM data files consisting of frequent use customers.
3. The TDC shall provide the Caltrans TMC with raw traffic volume, occupancy and speed data from the EL and the MF lanes.
4. The incident detection process shall be the responsibility of Caltrans. In the event that an incident does occur that would require temporary suspension of the ETS and/or EL closure, this shall be accomplished via a command issued by an authorized TMC Operator to the DMS module controllers.
5. TDC shall also interface to special equipment/tools used for EL enforcement.
6. TDC shall download the latest full CTOC tag status file at least daily to the zone controllers, and all portable handheld devices. Incremental tag status file updates shall also be automatically sent from the TDC to the zone controllers and the enforcement equipment/tools when this data is received from the RCSC.
7. There will be incidents on eastbound I-580 that may necessitate the closing of the EL or the diversion of MF traffic into the EL. These actions should only be taken by authorized Caltrans TMC staff, based on CHP confirmed motorist and TMC operator reports and the ACCMA ED.

Deleted: all MER on-board units

Deleted: readers

8. The TMC shall be included on the System WAN communication network to facilitate transmission of traffic data, CCTV video and EL DMS module override commands.
9. All actions taken by TMC personnel shall be logged into the EL TDC database, thereby allowing reports to be generated for reviewing procedure compliance when initiating the override.

4.1.3. EQUIPMENT INTERFACES

4.1.3.1. Zone Controller

1. The TDC shall interface to each tolling zone controller via a real-time Ethernet connection (requiring a controller with a real-time operating system).
2. The interface will support the transmission of raw traffic, transaction, and alarm/event data. It will also support the transmission of daily full and incremental tag status file updates.
3. The interface shall be automatic and not require human intervention.
4. The interface control document will be developed by the vendor during the system design phase of the project.

4.1.3.2. Dynamic Message Sign Price Display

1. The TDC shall interface with each DMS module controller via an Ethernet communications connection.
2. The interface shall be capable of supporting the transmission of message data, TOD pricing table, equipment status requests, equipment status codes and be NTCIP compliant.
3. The DMS Interface Control Document (ICD) shall be supplied by the vendor that is selected by the ETS Integrator.

4.1.4. TDC LOCATION

1. The location of the TDC shall be in a secure and environmentally controlled area which will only be accessible to authorized personnel.
2. The specific location of the TDC shall be defined by ACCMA and will be presented in the ETS RFP.

4.1.5. TDC HARDWARE REQUIREMENTS

1. The TDC system shall include the following equipment:
    - 1A - Primary and back-up computers that shall provide the processing capabilities that are described in this document. The back-up TDC computer shall automatically assume primary operating capabilities when the primary unit experiences failure;

- 1B - Personal Computer (PC) based workstations that shall provide all necessary operating functions at the TDC;
- 1C - Network printers capable of printing reports and other documents; and
- 1D - Switches, routers, CSU/DSU and other communication equipment to support the BATA RCSC file exchange process.

4.1.6. TDC OPERATING SYSTEMS

1. The TDC shall operate on the most recent, stable release of Microsoft's Windows Server operating system, or equivalent, as approved by the ACCMA ED.

4.1.7. TDC DATABASE REQUIREMENTS

1. The requirements for the TDC database shall be consistent with the ACCMA preferences, currently assumed to be Oracle-based, and will store raw traffic data from EL and MF lanes, detailed SOV transaction and trip records, historical and current DMS pricing tables, alarm/event data, current tag status file, zone controller configuration data, user authentication tables, system logs, spare parts inventory and asset management data,
2. To support the enforcement subsystem, it shall also serve as a repository for latest tag status file including updates.
3. The database shall provide sufficient data storage for meeting online data needs and off-line archival needs to retain data as required by law.
4. The online/archive storage limitations shall be accessible to approved users as editable system parameters.
5. The database shall store individual ETS alarm/events sent from the zone controllers installed at the tolling zones. Provided below is an example of this type of data:

   5A - Tolling zone ID;
   5B - EL Mode;
   5C - Transponder read date and read time;
   5D - Transaction record and alarm/event message ID;
   5E - Transaction record and alarm/event message sequence number;
   5I - Equipment status codes.

6. The TDC database shall store summary and detail transaction record information as shown below:

   6A - Date;
   6B - Time;
   6C - Transponder ID number;
   6D - User Type (future)
   6E - Direction of travel;

6F -Tolling zone ID;
6G - Equipment Status code

7. The database shall partition individual transaction records into uniform data segments for consistent data access, reporting and query performance.
8. The database shall store information related to status or state changes in the zone controller.
9. Transaction records shall be stored in a zone controller circular file format in addition to being forwarded in real time to the TDC to assure no transaction records are lost when communication with the TDC is not available. This stored data shall be uploaded to the TDC when communications are restored.
10. The database shall store summary information for each status segment.
11. The transaction database shall store information about the facility, tolling zones, toll rates, equipment statuses, and any other relevant data related to EL operations. Example data:

    11A - Facility ID;
    11B - Facility name;
    11C - Facility description;
    11D - Tolling zone ID;
    11E - Tolling zone name;
    11F - Tolling zone description;
    11G - Toll rate schedule ID; and
    11H - Toll rate effective date/time.

12. The database shall store information supporting the Maintenance Online Management System (MOMS) as described below:

    12A - Equipment type;
    12B - Equipment description
    12C - Equipment manufacturer;
    12D - Equipment model;
    12E - Equipment cost;
    12F - Equipment serial number;
    12G - Date put in service;
    12H - Projected service life; and
    12I - Current status.

13. The database shall store information about the business day and business week.
14. The database shall store information about the 4 possible EL modes of o operation, including:

    14A - Closed to all traffic;
    14B - Open to HOV traffic only;
    14C - Open to HOV and SOV (with FasTrak™ transponders) traffic only; and

14D - Open to all traffic.

15. The database shall store information regarding equipment that experiences degradation of operations and failures. Example data:

    15A - Fault type;
    15B - Date and time of fault;
    15C - Reporting employee ID;
    15D - Work order number;
    15E - Notification date and time;
    15F - Repairing employee ID; and
    15G - Date and time operations restored/fault corrected.

16. The database shall store information regarding system utilization and overall EL system performance, including the Level of Service for each 15-minute interval throughout each 24-hour period.

17. The database shall retain 12 months of detailed data online and 2 years of summary data online.

4.2. DYNAMIC MESSAGE SIGNS

4.2.1. PRIMARY DMS FUNCTIONS

1. The DMS pricing sign shall be located approximately 1/4 -mile upstream from each entry point to the EL facility and shall be the primary method of informing the public about the SOV price for travel to the each of the destinations shown on the sign (and all other destinations within the same Segment boundaries).

2. When the TDC trip processor calculates a toll rate for an entry point, the rate shall be communicated to the DMS module controller by Ethernet utilizing the IP address for that DMS module controller.

3. The DMS module controller shall active the Light Emitting Diodes (LED) needed to form the characters comprising a particular message pursuant to a request from the TDC.

4. The DMS controller shall acknowledge all messages received from the TDC and displayed on the sign.

5. TDC shall re-send messages after a time-out of the wait for an acknowledgement from the DMS module controller.

6. In addition to reporting what is being displayed on the sign at the time of the rate change, the DMS controller shall be polled by the TDC at regular intervals (at least every 60 seconds) for confirmation that the correct price is being displayed.

4.2.2. DMS EQUIPMENT REQUIREMENTS

1. The DMS shall be consistent with the Caltrans approved signage program.

2. The DMS sign shall consist of a fixed static sign panel with cutouts for inserting DMS modules corresponding to the number of destinations shown on the sign.
3. The EL DMSs shall combine static sign information panels with LED dynamic display modules.
4. The static part of the DMSs shall include static information (the EL downstream exit points, restricted hours, FasTrak™ logo, etc.).
5. The dynamic portion of the DMS shall include LED modules inserted in sign panel cut-outs to dynamically display prices to travel to the destinations shown on the sign panel. This module shall consist of at least 7 characters (alpha numeric) that are at least 12 inches in height.
6. The panel shall include an automatic feature that measures the ambient light and adjusts the intensity of the LEDs to be visible under all light conditions (full sun to full dark). In order to minimize the "halo" effect of certain colors, the LED color shall be amber.
7. The LED module controller shall be capable of reporting to the TDC what is being displayed along with an equipment status code if a problem is detected.
8. DMS display shall be activated by a sign controller which will be located either at roadside in an environmental enclosure or on the mounted sign.
9. DMS controller communications with the TDC's pricing application shall comply with the National Transportation Communications for ITS Protocol (NTCIP) and use Transmission Control Protocol/Internet Protocol (TCP/IP).
10. The DMS module controller shall have a unique IP address that identifies its location.

4.3. TOLLING ZONES

4.3.1. TOLLING ZONE OVERVIEW

1. A series of tolling zones along the eastbound I-580 corridor shall be situated near each access point to the EL in order to detect FasTrak™ transponders and to monitor vehicles as they travel through the EL.
2. The tolling zones shall be located just downstream from the EL ingress and covers the width of the EL.
3. Raw traffic and transaction data shall be transmitted to the TDC subsystem from the toll zones, where this data will be used to build EL trip records.

4.3.1.1. Primary Tolling Zone Functions

1. The primary functions of the tolling zones shall be to:
    - 1A - Detect and sequence vehicles through the payment zone;

- 1B - Search for and read transponders;
- 1C - Create raw vehicle, transponder, and status records;
- 1D - Visually alert CHP officers of possible EL violators; and
- 1E - The ETS shall have the capability to flag certain characteristics to accommodate future traffic conditions or ACCMA policies.

2. In order to accomplish these primary tasks, the ETS at the tolling zones shall utilize the following equipment:
   - 2A - A lane controller, which shall be an industrial Personal Computer (PC) that performs the logical functions required to create raw traffic, transponder, and status records and act as the central point for all of the tolling zone equipment;
   - 2B - An RFID-based Automatic Vehicle Identification (AVI) system; and
   - 2C - An enforcement beacon subsystem
   - 2D – Vehicle detector station/system
3. A number of supporting functions shall also be carried out by the tolling zone controller to successfully perform the primary functions required for EL operations.
4. The system shall be responsible for monitoring maintenance and self-diagnostic messages sent from the roadside hardware described above and reporting on any system and/or equipment degradations or failures.
5. The tolling zone controller shall also receive FasTrak™ tag status files and updates from the TDC, which are files created by the RCSC on a daily basis that designate each transponder in the FasTrak™ system as ‘good/active’ or ‘bad/inactive,’ etc.
6. The tolling zone controller shall store and transmit raw FasTrak™ transaction records using an Ethernet connection to the TDC.
7. Although a tolling zone shall be located downstream of every EL entry point, a toll-paying customer shall only be required to pay one toll for each trip, regardless of the length or duration.
8. The TDC shall identify when and where a vehicle enters and exits the EL system and only creates one trip record comprised with one or more transaction records for each individual trip.

4.3.1.2. Tolling Zone Locations

1. Each tolling zone shall be located on the downstream side of its respective EL entry point and each location shall consist of one set of the ETS equipment that is described above, as well as all necessary supporting equipment including cabling, circuit and lightning protection devices, uninterruptible power supply (UPS) devices, communication equipment and devices, environmental equipment enclosure (s), and other electronics.
2. The method of toll collection shall ensure that traffic flow is not impeded and vehicles may travel through the tolling zone at speeds consistent with LOS C/D.
3. Since the EL system only consists of one lane of traffic, each vehicle shall be required to pass through a tolling zone downstream of entry point they encounter.

4.3.2. ZONE CONTROLLER

1. The tolling zone controller shall control and monitor the toll collection activities at each tolling zone and be primarily responsible for gathering FasTrak™ transaction data and transmitting that information to the TDC, in a secure environment, and without duplication, for trip compilation.
2. The zone controller shall also interface with the TDC to receive daily FasTrak™ tag account status files and updates on at least a daily basis.

4.3.2.1 Zone Controller Primary Functions

1. The primary functions of the ETS lane controller shall be to:
    - 1A - Collect and transmit vehicle count and transponder read data;
    - 1B - Provide visual feedback of possible violations, through the use of an enforcement beacon installed at the tolling zone in such a position that it can be easily viewed by CHP officers;
    - 1C - Monitor its peripheral tolling zone equipment (i.e. FasTrak™ reader, antenna, vehicle detection system equipment, and enforcement beacon) and report on the status of these pieces of equipment; and
    - 1D - Receive daily tag status files and updates files from the TDC.
2. The zone controller shall accommodate a system administration and maintenance interface. This interface shall be used by operations and maintenance personnel to accomplish tasks such as modifying system configuration files, updating access authorization tables, accessing system logs, extracting transaction data, performing preventive maintenance tasks, etc.
3. The zone controller shall be capable of storing no less than 30 days of traffic and alarm/event data and transaction records.

4. The zone controller shall store no less than 10 million FasTrak™ transponder accounts within the tag status file.
5. All zone controller messages (e.g. traffic alarm/event, transaction and maintenance records) shall contain a unique sequence number.
6. The zone controller shall include at least the following information in the transaction record:
    - 6A - Transponder number;
    - 6B - Transponder status;
    - 6C - Transponder handshake count;
    - 6D - Zone controller date;
    - 6E - Zone controller time;
    - 6F - VDS direction data flag
    - 6G – VDS speed measurement; and
    - 6H - Equipment status code (s).
7. The zone controller's vehicle sequencing logic shall be self-correcting.
8. The zone controller shall record all transponders that are read by the FasTrak™ tolling zone subsystem.
9. The zone controller shall be able to operate normally without network communications, storing current records for later transmission to the TDC.

4.3.2.1.1. Equipment Monitoring and Control

1. The lane controller shall monitor the following peripheral equipment through real-time data connections:
    - 1A - Vehicle detection system equipment;
    - 1B - FasTrak™ transponder reader;
    - 1C - FasTrak™ antennas;
    - 1D - Enforcement beacon; and
    - 1E - Uninterruptible power supply and communication transmission equipment that is located at the tolling zone.
2. The system monitoring functionality shall include the ability to receive maintenance status messages from all subsystems and it shall incorporate

logical processes, local to the zone controller, which evaluate inputs and outputs from multiple sources and create maintenance alarms based upon sets of rules and unexpected conditions.

3. The maintenance alarms that are generated by the zone controller shall be sent to a maintenance on-line management subsystem (MOMS).
4. The MOMS shall be responsible for writing equipment status and alarm data into a database and issuing dispatch alerts and building work orders that describe maintenance problems that need to be addressed. Technicians dispatched to respond to a work order shall close the work order by describing the problem, parts and equipment repaired and replaced (e.g., P/N, serial no., model, manuf., device/equipment warranty status), arrival time, departure time, and condition assessment.

4.3.2.1.2. Zone Controller Data and File Transmission

1. The EL controllers shall be connected to the TDC through an Ethernet connection and transmit files to the TDC server in real-time.
2. The zone controller shall transmit traffic information, transaction records, equipment diagnostics and maintenance alarm/event data.
3. The zone controllers shall receive, at a minimum, daily FasTrak™ tag status file and updates, system configuration files, access authorization tables, and time synchronization.
4. The zone controller's serial ports shall be configurable as either RS-232 or RS-422.
5. Serial communications interfaces shall provide for error detection protocols necessitating retransmission of the data or command.

4.3.2.2. Lane Controller Equipment Requirements

Under normal conditions, the zone controller shall operate in an automated fashion without intervention from operational personnel.

1. All ETS functions, including but not limited to, transaction record assembly and transmission shall be designed to function independent of human interaction.
2. The zone controller shall be environmentally hardened and housed in an environmentally shielded and controlled enclosure to operate under all weather conditions historically recorded in the Bay Area.
3. The zone controller shall be designed to support discrete input and output signal lines and use optical isolation, MOV, and other industry standard circuitry protection.
4. The zone controller shall store data redundantly.
5. The zone controller shall provide for a local user interface for maintenance purposes.

6. The zone controller data storage process shall be based on First in First out (FIFO) data retainage process.
7. The zone controller performance shall be ample to handle all lane processes as designed at a rate of 2,400 vehicles per lane per hour, with 85% of those vehicles having transponders.
8. For any 10 second period, the zone controller shall be capable of handling all EL processes for transponder vehicle passage rates of 4,800 vehicles per hour, assuming that all vehicles have transponders.
9. The tolling zone system shall capture transponder reads for 99.98% of the vehicles with properly mounted valid transponders passing through the tolling zone.
10. The tolling zone system shall capture transponder reads for less than 0.01% of the transponders traveling in the MF lane closest to the EL (leftmost MF lane).
11. The tolling zone system shall be capable of determining the direction of travel for all vehicles in the EL with an error rate in the determination of travel direction of no more than 0.01%.

4.3.2.3. Lane Controller Operating System

1. The zone controller Operating System (OS) shall be robust enough to meet all RFP requirements to support operations of the tolling zone subsystems.
2. The OS of the zone controller shall function in such a way that it allows for the real-time processing of transaction records and transmission across an Ethernet network as well as remote, real-time user connections (for maintenance purposes).
3. The zone controller shall provide TCP/IP network support and TCP utilities such as telnet, SNMP, SMTP, and FTP.

4.3.2.4. Zone Controller Interface to the Toll Data Center

1. Each zone controller shall maintain a real-time interface with the TDC. This interface shall allow for the transmission and reception, in real-time, of any data collected and assembled in the lane and any data compiled at the TDC which is necessary for tolling zone subsystem operations.
2. The zone controller to TDC interface shall be fully automated and not require human intervention.
3. The zone controller shall broadcast lane alarm/events in near real-time to the TDC to support the monitoring and response activities carried out by operations or maintenance personnel.
4. The zone controller shall transmit a periodic heartbeat, or status, message to the TDC.

5. If communication between the zone controller and the TDC fails, the zone controller shall periodically attempt to re-establish the connection until the connection is made.
6. The zone controller shall periodically (at least daily) receive tag status files and updates from the TDC, upon which various sanity checks shall be performed to ensure file validity prior to moving to static memory. Typical sanity checks would include checking the file type, size, header and footer data.
7. The zone controller shall acknowledge TDC-initiated command execution for execution.

4.3.2.5. Zone Controller Equipment Interface

1. All zone controller interfaces to peripheral equipment shall incorporate means of detecting whether the equipment is operating properly or malfunctions.

4.3.2.5.1. Zone Controller Interface to the Vehicle Detection Systems

1. The interface between the zone controller and the VDS equipment shall be in real-time.
2. Raw traffic data that is gathered shall consist of occupancy, speed and volume. This data will be used both in building a transaction record and sent directly to the TDC for use in the dynamic pricing software module.

4.3.2.5.2. Zone Controller Interface to the FasTrak™ Reader

1. The interface between the zone controller and the FasTrak™ transponder reader shall be in real-time.
2. The bidirectional interface shall allow for the exchange of zone controller commands and FasTrak™ transponder data.

4.3.2.5.3. Zone Controller Communication with Enforcement Beacon

1. The zone controller shall use discrete I/O communication with the tolling zone enforcement beacon to immediately activate the beacon when a valid FasTrak™ transponder is processed.

4.3.2.5.4. Uninterruptible Power Supply

1. The zone controller shall interface with a UPS to ensure that battery back-up is available to the controller if utility electrical service fails.
2. The use of UPS equipment shall allow that the zone controller software to be remotely shut down in an orderly fashion if power is not restored prior to expiration of the UPS runtime.

4.3.3. VEHICLE DETECTION SYSTEM EQUIPMENT

4.3.3.1. VDS Equipment to be Deployed

1. The primary functions of the VDS equipment shall be to accurately and in near real-time collect volume, occupancy, and speed data for all vehicles traveling in the EL.

2. Inductive loops shall be installed along the EL, approximately one mile apart. Double loops shall be installed according to the most currently available Caltrans loop installation standard.
3. Remote Traffic Microwave Sensor (RTMS) devices shall be installed, on the outside shoulder, and shall collect volume, occupancy, and speed data from all vehicles traveling in the MF lanes. RTMS devices are miniature radar units, which operate in either of two microwave bands, and transmit a low-power microwave signal of constantly varying frequency in a fixed fan-shaped beam.
4. The RTMS subsystems shall also be used as back-up in collecting volume, occupancy, and speed data from the EL if the loop detector experiences failure.

4.3.3.2. VDS Equipment Requirements

1. Except at each toll zone, VDS equipment shall include an independent controller supporting both loop detector and RTMS devices and shall send raw traffic data directly to the TDC using landline or wireless communications.
2. The VDS controller shall include functionality that allows for a direct maintenance data connection, both locally and remotely.
3. The VDS equipment shall detect all vehicles that pass through a detection zone with an accuracy of at least 99.9% in all weather conditions.
4. The VDS controller shall support self-diagnostic and fault detection messages to the lane controller.
5. The VDS equipment shall detect volume and calculate speed and occupancy data of vehicles traveling no less than three feet apart in the EL at the above described accuracy rate.

4.3.4. FASTRAK™ READER AND ANTENNA

4.3.4.1. Primary Functions of the FasTrak™ Reader and Antenna

1. The FasTrak™ reader, and its peripheral equipment including the antenna, shall accomplish the primary functions of transponder detection, handshake, decoding and data writing process.
2. The reader's state, for example whether the RF module searches for transponders or not, shall be determined by the zone controller.
3. The FasTrak™ reader and antenna shall operate within the technical requirements presented in the Title-21 specifications.

4.3.4.2 Reader and Antenna Equipment Requirements

1. The FasTrak™ transponder reader and antenna shall be compatible and interoperable with all other electronic tolling systems that are deployed in California by complying with all operating and configuration requirements presented in the Title-21 specification.

2. As transponders are read when they travel through the tolling zone, status indicator beeps shall be activated in exactly the same manner as other Bay Area FasTrak™ facilities.
3. The reader/antenna shall be required to read a transponder mounted inside a vehicle traveling at speeds from 0 to 100 miles per hour.
4. The reader shall transmit transponder ID number and tag status to the zone controller, where this data will be supplemented by date, time, tolling zone location code, and equipment status code to build a transaction record.
5. The AVI subsystem shall include lane discrimination functionality that ensures only transponders in the EL are read (not transponders in the adjacent MF lane.
6. FasTrak™ antennas shall be installed over the middle of the EL and shall be capable of reading transponders that are installed either on the windshield behind the rear-view mirror or on the lower left portion of the windshield (approximately 2 inches from the bottom and 2 inches from the edge), as well as any transponders mounted to a vehicle's bumper.
7. The reader shall not be located more than 75 feet from the overhead mounted antenna.
8. The AVI subsystem shall record transponders with an accuracy of at least 99.98%.

4.3.5. TOLLING ZONE BEACON

4.3.5.1. Primary Functions of the Tolling Zone Beacon

1. The primary function of the enforcement beacon shall be to visually alert CHP officers to the presence of a potential EL violator in the tolling zone.
2. The beacon shall have the illumination capability to provide visual feedback to CHP officers that are located within 100 feet of the beacon.
3. The beacon shall be located to allow vehicle operators having a properly mounted valid transponder when traveling through a tolling zone to see the device illuminate.

4.3.5.2. Beacon Equipment Requirements

1. The tolling zone beacons shall provide a visual signal and be directly controlled by the lane controller.
2. The beacons shall be installed at the tolling zone in such a location that allows it to be seen by CHP officers and qualified users that are driving through a tolling zone.

4.4 VEHICLE DETECTION STATIONS

1. As described in Section 4.3.3, the VDS equipment shall be deployed to measure real-time traffic data (i.e., volume, occupancy and speed) that is used to both

build a EL transaction record and for direct input into the dynamic pricing software module.

2. VDSs shall collect the current traffic volume, occupancy and speed data from each lane at roadway stations shown on the civil construction plans. This information shall be transmitted to the TDC located at the ACCMA facility for processing prior to input into the dynamic pricing software module.

4.4.1. VDS LOCATIONS

1. An analysis was conducted to determine the appropriate ingress and egress locations which in turn helped to determine the location of the VDS equipment.
2. Inductive loops shall be installed in the EL and RTMS devices shall be installed off of the roadway outside shoulder for side-fire across all MF and EL.
3. Loops shall collect traffic volume, occupancy and speed data from the EL and the RTMS devices shall collect the same traffic data from the MF and EL, which shall be used by the dynamic pricing software module to calculate traffic trends in the MF for validating measured conditions in the EL.

4.4.2. VDS EQUIPMENT REQUIREMENTS

1. Except at toll zones, VDS equipment shall be installed in standard Caltrans traffic signal controller cabinets as indicated in the preliminary plans.
2. The VDS equipment shall be designed and operate in accordance with all current Caltrans specifications.
3. The VDS equipment shall be installed with a Model 170E Controller, which is the Caltrans standard for such equipment.

4.4.3. VDS INSTALLATION REQUIREMENTS

1. The VDS controller cabinets shall be installed off the outside roadway shoulder adjacent to corresponding vehicle detection loops.
2. Cabinets shall be easily accessible from the mainline shoulder by maintenance and operations personnel.
3. Unless outside the clear zone, VDS cabinets shall be protected from traffic by installing behind a guardrail or barrier.
4. These cabinets shall be installed out of any flood plain and the foundation at an elevation sufficiently above ground water level.
5. The loop detectors and RTMS devices shall be installed in accordance with standard Caltrans practice and the manufacturers' recommendations.

4.4.4. INTERFACE TO CALTRANS TRAFFIC MANAGEMENT CENTER

1. The VDS data shall be sent to the Caltrans TMC, via a TDC communications carrier network link, for operational use by Caltrans.
2. This communications link shall allow Caltrans staff to issue commands to display messages on the DMS pricing signs that close, or open selected

Segments or all Segments if an incident or maintenance work warrants Caltrans temporary control of the EL operation.

3. The ACCMA ED shall be notified of the override decision when incidents occur that require Caltrans TMC intervention.

4.5. CLOSED CIRCUIT TELEVISION CAMERAS

1. Closed Circuit Television (CCTV) cameras shall be deployed for traffic surveillance, monitoring of the tolling zones, confirming the message displayed on the DMS pricing sign, and remotely supporting enforcement details.
2. CCTV cameras shall also be used to assist Caltrans staff in detecting and confirming incidents and to track the progress of incident response and clearance.
3. Video from these cameras shall be sent to the TDC and then to the TMC where it is made available to the ACCMA and other third parties over the Internet. However, during normal operational periods ACCMA staff shall have remote control over the pan, tilt and zoom camera features and Caltrans staff shall have only view access. During emergency situations, control of the video shall be provided to TMC staff.

4.5.1. CCTV CAMERA LOCATIONS

1. The CCTV cameras shall be installed at locations shown on the civil construction plans according to the preliminary plans.

4.5.2. CCTV CAMERA REQUIREMENTS

1. The CCTV camera equipment shall include the following components:
    - 1A - Dome camera system with day/night capability;
    - 1B - Camera mounting pole and mounting bracket assembly;
    - 1C - Pole foundation;
    - 1D - CCTV control cabinet; and
    - 1E - Video and communication components and cables.
2. CCTV cameras shall be able to turn 360 degrees and contain pan, tilt and zoom capabilities.
3. The CCTV subsystem shall use Ethernet-based communications and protocols.

4.6. EL ENFORCEMENT SUBSYSTEM

4.6.1. EL ENFORCEMENT OVERVIEW

1. The EL concept of allowing SOVs to pay a toll to utilize unused capacity in the HOV lane adds a significant degree of complexity to system enforcement as compared to HOV lane enforcement. Enforcing the EL requires the CHP officers to determine if a toll was paid by the SOV driver and to visually determine the number of occupants in the vehicle if a valid toll was not recorded.

2. The high-level objective of the EL enforcement process is to provide fair and transparent enforcement which results in an acceptable level of EL use compliance and public acceptance.

4.6.1.1. EL Enforcement Process

1. The EL will be separated from the MF lanes by double solid lines with no physical barrier.
2. Users shall only be able to legally access the EL at designated access points marked with on-ramp and off-ramp striping.
3. Tolling zones shall be located just downstream from the EL entry point.
4. EL enforcement will be accomplished by CHP officers who are either parked in barrier protected enforcement areas, remotely from their moving patrol cars using handheld enforcement devices in conjunction with the beacons.
5. When a CHP officer observes an SOV in the EL, they will need to determine if the SOV user has paid the toll using a valid transponder. Accordingly, the officer shall rely on an indication from the tolling zone beacon and that the toll has been paid. This indication and alert shall be provided within 1.0 second of the vehicle traveling through the tolling zone to allow the visual correlation of user observation with tolling zone beacon activation.

4.6.1.2. System Enforcement Approach

1. There shall be two methods for providing notification to CHP officers that a EL violation has occurred:
   - 1A - Tolling Zone Beacon: The zone controller, which is located at the tolling zone, shall initiate a signal every time a valid tag read occurs when a transponder equipped vehicle traverses a tolling zone. The beacon shall illuminate each time a valid FasTrak™ transaction record is built. This verification shall be made automatically by the lane controller by matching the transponder ID number read to an entry on the most recent FasTrak™ tag status file. Therefore, if the beacon does not illuminate the user must qualify as HOV to be legally in the EL. If a CHP officer determines the vehicle is not a qualified HOV user based on observed occupants, the officer has the option to pull the vehicle over to determine whether the vehicle operator is attempting to violate the EL toll. If there is a transponder in the vehicle, the officer shall read the transponder with a small handheld transponder reading device to determine whether their account is in good standing. If it is not, then an EL violation has occurred and the officer will act accordingly.

4.6.2. ENFORCEMENT SYSTEM PRIMARY REQUIREMENTS

1. The primary functions of each enforcement system component are discussed below.

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Deleted: <#>1B - Mobile Enforcement Reader: The MER is a FasTrak™ antenna mounted on CHP patrol cars allowing an officer to determine whether passing vehicles are equipped with a transponder that is in good standing. The officers can either park on the shoulder of the road or be traveling along the corridor and interrogate passing vehicles by touching the screen of a Personal Digital Assistant (PDA) device which triggers an RF read signal. An audible sound and screen display will inform the CHP officer if the vehicle is equipped with a valid transponder The MER antenna shall then attempt to detect a FasTrak™ transponder and, if successful, scan the transponder ID number against the tag status file resident on the MER controller to determine whether the transponder is linked to a valid FasTrak™ account. A MER shall permit EL enforcement activities by CHP officers while traveling at prevailing highway speeds in either the EL or MF lanes. Once the officer determines that a potential violator has been detected, he/she would pursue the suspected violator and request that the user pull over.¶
<#>PDA devices are used in combination with a MER. The PDA is a different type of unit integrated into a hand-held enforcement device.¶

- 1A - Toll Data Center: The TDC accepts the tag status files and updates along with requested customer data from the BATA RCSC and is responsible for passing on this information to other components of the enforcement subsystem. Tag status information is transmitted to the zone controllers in each tolling zone on a periodic basis. Tag status data shall also be downloaded to the handheld device over a high-speed connection.

- 1B - Zone Controller: As described previously, the zone controller shall be responsible for the monitoring and control of all equipment deployed at a tolling zone and for the transmission of transaction records and alarm/event data to the TDC. For the enforcement subsystem, the zone controller supported by the FasTrak™ reader, shall determine a valid read and illuminate the beacon light.

- 1C - Handheld Device: This unit shall allow the CHP officer to obtain account status information by scanning the transponder with the handheld device. This will allow CHP motorcycle officers to enforce the EL.

4.6.3. HANDHELD ENFORCEMENT DEVICE

1. The handheld device shall allow the CHP motorcycle enforcement officers to confirm whether or not an SOV has a transponder that is linked to an account in good standing.

4.6.3.1. Handheld Device Primary Functions

1. The hand held device shall provide the following functions:

- 1A - The handheld device shall be able to read a transponder and determine whether it is linked to a FasTrak™ account that is in good standing; and

- 1B - The handheld device shall operate within the FasTrak™ Title-21 RFID protocol and operating standards.

- 1C - The handheld device shall receive tag status file data which includes the daily updated list of the valid and invalid transponders recognized by the BATA RCSC. This data shall be downloaded when the handheld device is connected to the TDC Wide Area Network (WAN).

- 1D - The handheld device shall receive tag status updates periodically throughout the day. This data shall be downloaded to the handheld over a secure, high-speed wireless communications connection.

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<#>The MER shall allow CHP enforcement officers to confirm that an SOV is equipped with a transponder that is linked to an account that is in good standing.¶
4.6.3.1. MER Primary Functions¶
<#>The MER shall provide the following functions:¶
<#>1A - The MER shall be able to read a transponder and determine whether it is in good standing or not.¶
<#>1B – The MER shall be able to read on-board transponders, at highway speeds, at distances of up to 30 feet.¶
<#>1C - The MER shall operate in compliance with the Title-21 FasTrak™ RFID specifications, protocol and operating parameters.¶
<#>1D - The MER shall detect on-board transponders within the operating requirements that are used by the FasTrak™ readers and antennas that are installed at the EL tolling zones.¶
4.6.3.2. MER Equipment Requirements¶
<#>The MER shall be weather proof, environmentally hardened for use outside and suitable for installing on and within CHP patrol cars. ¶
<#>The PDA display screen shall be visible under all lighting conditions. ¶
<#>Power to the MER antenna an... [2]

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- 1E - The handheld device shall contain software to compare a transponder's identification with the tag status file and determine if the transponder is linked to an account in good standing; and
- 1F - The handheld device shall display information in an intuitive format that requires minimal interaction on the part of the user.

4.6.3.2. Handheld Equipment Requirements

1. The hand held device shall be small enough in size, weather proof, environmentally hardened for use outside and suitable for use by a CHP motorcycle officer.
2. The handheld device display screen shall be visible under all ambient lighting conditions.
3. The handheld device shall provide CHP officers with readily accessible information on transponder identification numbers and current account status information.
4. The handheld device shall be able to receive data over a secure, high-speed, wireless WAN connection.
5. The handheld device shall also receive tag status file and update downloads on, at least, a daily basis.
6. A rechargeable battery shall power the handheld device that allows use for up to 12 hours of continuous use.

5. BATA REGIONAL CUSTOMER SERVICE CENTER

1. The existing BATA Regional Customer Service Center (RCSC) software may need to be modified, by BATA's back office service provider, to support required EL functionality.
2. The current business rules, procedures and practices of the BATA RCSC shall remain the same, but some changes will be necessary to accommodate the new EL customers. One area in which changes will be required is to modify the BATA FasTrak™ account statements to include I-580 EB EL trips.
3. Other changes may be required to interface the EL operation with the RCSC back office processing, that makes use of existing data elements, including agency codes, file names, etc.

5.1. INTERFACE TO THE ACCMA

1. The BATA RCSC shall support direct interface to the FasTrak™ account management, transponder tracking system, revenue transfers and other system reports for the benefit of ACCMA CSR staff.

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<#>PDAs shall be used in support of both the MER and hand held enforcement devices. ¶
<#>The PDA shall provide CHP officers with readily accessible information on transponder identification numbers and current account status information. ¶
<#>The PDA shall also receive tag status file and update downloads on, at least, a daily basis.¶
4.6.5.1. PDA Primary Functions¶
<#>The PDA shall provide the following functions:¶
<#>1A - The PDA shall receive tag status file data which includes the daily updated list of the valid and invalid transponders recognized by the BATA RCSC. This data shall be downloaded when the PDA is connected to the TDC Wide Area Network (WAN).¶
<#>1B - The PDA shall receive tag status updates periodically throughout the day. This data shall be downloaded to the PDA over a secure, high-speed wireless communications connection.¶
<#>1C - The PDA will contain software to compare a transponder's identification with the tag status file and determine if the transponder is linked to an account in good standing; and¶
<#>1D - The PDA shall display information in an intuitive format that requires minimal interaction on the part of the user.¶
4.6.5.2. PDA Equipment Requirements¶
<#>The PDA shall be small in size, weather proof, environmentally hardened for use outside and suitable for use by CHP motorcycle officers. ¶
<#>The PDA display screen shall be visible under all ambient lighting conditions. ¶
<#>The PDA shall be able to receive data over a secure, high-speed, wireless WAN connection. ¶
<#>A rechargeable battery shall power the PDA that allows use for up to 12 hours of continuous use. ¶

2. When accessing customer accounts, ACCMA Customer Service Representatives (CSRs) shall be able to view specific EL trips as well as account profile information.

5.2. RCSC SYSTEM REQUIREMENTS

1. The RCSC interface requirements in support of the EL shall be presented to the ETS Integrator in the form of the BATA RCSC Interface Control Document (ICD). This document shall be incorporated into the ETS RFP as an appendix.

5.3. EL CUSTOMER STATEMENTS

1. Current BATA FasTrak™ customer statements shall be modified to include actual EL trips.

5.4. EL CUSTOMER AGREEMENT

1. The customer agreement required for obtaining a FasTrak™ account and transponder with the BATA RCSC shall be identical to joining the program as a user of the Caltrans toll bridges, the Golden Gate Bridge, TCA, SR-91 and SR-125.

6. EL COMMUNICATIONS NETWORK INFRASTRUCTURE

1. The EL Communications Network encompasses all communications between the devices in the field and the Tolling Data Center.

6.1 TOLLING ZONES TO TOLL DATA CENTER

1. Due to the distances between the Tolling Zones and the Toll Data Center (TDC), and the relatively high costs associated with adding new underground infrastructure, the communication links between the Tolling Zones and the TDC shall utilize either leased data communication services or a wireless communication network solution, whichever has the lowest monthly service fee.
2. These communication links shall provide a minimum 1.5Mbps data rate and shall have a high level of availability (99.999%).

6.2. TOLLING ZONE TO TOLLING ZONE

1. Tolling Zone to Tolling Zone communication shall be used to provide a redundant or backup communications path to the Tolling Data Center should the primary communications path fail.
    - 1A - Between the East and Central Tolling Zones this communication path shall be provided by a point to point WiMAX wireless link if duct is not available to install fiber optic cable; and
    - 1B - Between Central and West Tolling Zones a redundant communications path shall be provided by point to point WiMAX wireless link if duct is not available to install fiber optic cable

6.3 INTRA TOLLING ZONE

1. Intra Tolling communications is defined as the communications between the zone controller and the field device controller in proximity to the Tolling Zone. Field devices include the VDS, DMS pricing sign and CCTV cameras.

    - 1A - The coverage for any intra-TZ communications infrastructure is 0.5 mile per tolling zone.

    - 1B - Secure point to point wireless communication links shall be used if duct is not available to install fiber optic cable. For non-line-of-sight situations, repeaters shall be used.

    - 1C - Conduit has to be installed to provide electrical service to field devices as shown on the as-built construction drawings. .Additional conduit installation shall be required where existing conduit is not sufficient to meet the required electrical feeder runs.

6.4 TOLL DATA CENTER TO ENFORCEMENT DEVICES

1. Communications between the TDC and enforcement devices, including the handheld devices, shall utilize a secure, high-speed data connection to the handheld devices over a cellular data network.

    - 1A – The cellular data communications network shall provide uninterrupted coverage over the entire length of the project.

    - 1B – The cellular data communications network shall provide a minimum data rate of 128kbps

    - 1C – The communication link between the enforcement device and the TDC shall utilize Virtual Private Network (VPN) tunneling to establish a secure and encrypted connection.

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I. CONCEPT OF OPERATIONS (under separate cover)

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MER	Mobile Enforcement Reader

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4.6.3. MOBILE ENFORCEMENT READER

The MER shall allow CHP enforcement officers to confirm that an SOV is equipped with a transponder that is linked to an account that is in good standing.

4.6.3.1. MER Primary Functions

The MER shall provide the following functions:

1A - The MER shall be able to read a transponder and determine whether it is in good standing or not.

1B – The MER shall be able to read on-board transponders, at highway speeds, at distances of up to 30 feet.

1C - The MER shall operate in compliance with the Title-21 FasTrak™ RFID specifications, protocol and operating parameters.

1D - The MER shall detect on-board transponders within the operating requirements that are used by the FasTrak™ readers and antennas that are installed at the EL tolling zones.

4.6.3.2. MER Equipment Requirements

The MER shall be weather proof, environmentally hardened for use outside and suitable for installing on and within CHP patrol cars.

The PDA display screen shall be visible under all lighting conditions.

Power to the MER antenna and reader shall be provided by the CHP vehicle's internal power source to ensure continuous use.